INSTRUCTION MANUAL

Model 174
Digital Multimeter

[Contains Operating and Servicing/Calibration
Information for Models
174, 1722, 1728, 1740, 1744 and 1745.]

KEITHLEY INSTRUMENTS

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INSTRUCTION MANUAL

Digital Multimeter

Model 174

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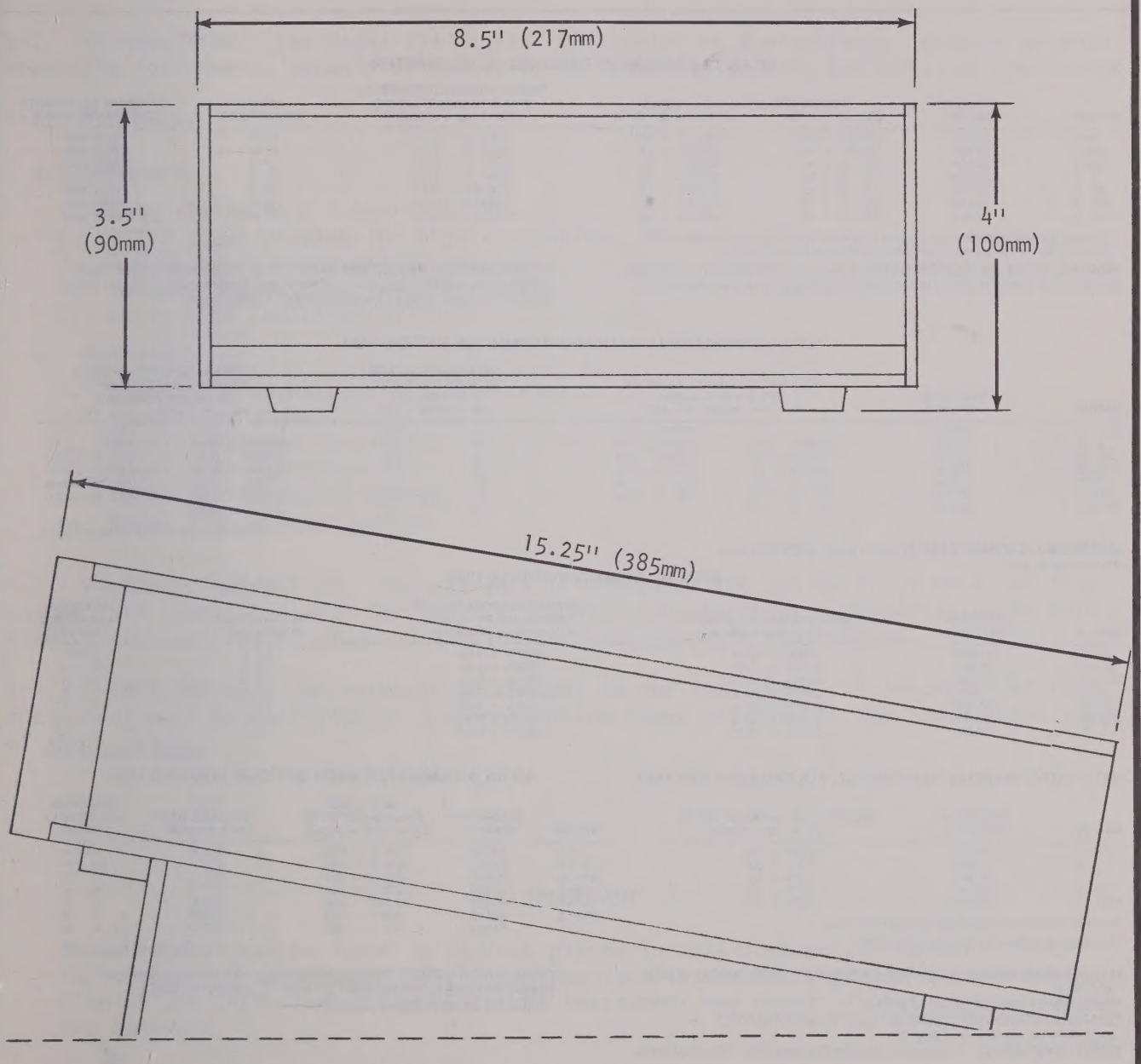


FIGURE 1. Dimensional Data.

SPECIFICATIONS

AS AN AUTO/MANUAL RANGING DC VOLTMETER

RANGE	MAXIMUM READING	ACCURACY [±(% of rdg + digits)] (24h, 25° ±1°C)	ACCURACY [±(% of rdg + digits)] (6 months, 20°-30°C)	TEMPERATURE COEFFICIENT 0° to 20°C and 30° to 50°C ±(% of rdg + digits)/°C	INPUT RESISTANCE	MAXIMUM ALLOWABLE CONTINUOUS INPUT
3mV*	2.9999	0.015% + 2d**	0.02 % + 2d**	0.002 % + 0.1d**	$10^9\ \Omega$	250V peak
30mV*	29.999	0.012% + 1d**	0.017% + 1d**	0.002 % + 0.1d**	$10^9\ \Omega$	250V peak
300mV	299.99	0.01 % + 1d	0.013% + 1d	0.001 % + 0.1d	$10^9\ \Omega$	1200V peak
3 V	2.9999	0.01 % + 1d	0.013% + 1d	0.001 % + 0.1d	$10^9\ \Omega$	1200V peak
30 V	29.999	0.01 % + 1d	0.013% + 1d	0.0015% + 0.1d	$10^7\ \Omega$	1200V peak
300 V	299.99	0.01 % + 1d	0.013% + 1d	0.0015% + 0.1d	$10^7\ \Omega$	1200V peak
1000 V	1200.0	0.01 % + 1d	0.013% + 1d	0.0035% + 0.1d	$10^7\ \Omega$	1200V peak

*Manual or remote ranges only. Analog output on these two ranges, gain of 100.
**When properly zeroed with front-panel control, see zero stability.

NORMAL MODE REJECTION RATIO: Greater than 100dB on 3mV range, greater than 80dB on 30mV range and higher ranges at line frequency.

COMMON MODE REJECTION RATIO: (1k Ω unbalance) Greater than 120dB at dc and line frequency on 3mV and 30mV ranges. Greater than 100dB on higher ranges, except 80dB on 1000V range.

WITH AUTO/MANUAL RANGING OHMMETER OPTION 1744

RANGE	MAXIMUM READING	ACCURACY (6 months, 20°-30°C) ±(% of rdg + digits) HI — mode — LO		MAXIMUM VOLTAGE ACROSS UNKNOWN ON RANGE* HI — mode — LO		TEMPERATURE COEFFICIENT (0° to 20°C and 30° to 50°C) ±(% of rdg + digits)/°C HI — mode — LO	
300 Ω	299.99	—	0.035% + 2d	—	0.3V	—	0.003% + 0.1d
3k Ω	2.9999	0.035% + 1d	0.035% + 1d	3V	0.3V	0.003% + 0.1d	0.003% + 0.1d
30k Ω	29.999	0.035% + 1d	0.035% + 1d	3V	0.3V	0.003% + 0.1d	0.003% + 0.1d
300k Ω	299.99	0.035% + 1d	0.05 % + 1d	3V	0.3V	0.003% + 0.1d	0.004% + 0.1d
3MΩ	2.9999	0.05 % + 1d	0.2 % + 1d	3V	0.3V	0.004% + 0.1d	0.02 % + 0.1d
30MΩ	29.999	0.2 % + 1d	1.0 % + 1d	3V	0.3V	0.02 % + 0.1d	0.15 % + 0.1d
300MΩ	299.99	1.7 % + 1d	—	3V	—	0.15 % + 0.1d	—

*Maximum open-circuit voltage, 5 volts.

MAXIMUM ALLOWABLE INPUT: 350V peak, 240V rms line frequency or dc.

WITH DC AMMETER OPTION 1745

RANGE	MAXIMUM READING	ACCURACY (6 months, 20°-30°C) ±(% of rdg + digits)	TEMPERATURE COEFFICIENT 0° to 20°C and 30° to 50°C ±(% of rdg + digits)/°C	VOLTAGE DROP (at full-range)	MAXIMUM ALLOWABLE INPUT
3 μA	2.9999	0.06% + 10 d	0.003% + 0.6d	0.3 V	2.5mA
30 μA	29.999	0.05% + 2.5d	0.003% + 0.4d	0.3 V	25. mA
300 μA	299.99	0.05% + 2.5d	0.003% + 0.4d	0.3 V	4. A*
3mA	2.9999	0.05% + 2 d	0.003% + 0.4d	0.3 V	4. A*
30mA	29.999	0.05% + 2 d	0.003% + 0.4d	0.3 V	4. A*
300mA	299.99	0.06% + 2 d	0.003% + 0.4d	0.35V	4. A*
3 A	2.9999	0.08% + 2.5d	0.007% + 0.3d	0.7 V	4. A*

*Internally fused at 4A, 250V.

WITH AUTO/MANUAL RANGING AC VOLTAGE OPTION 1740

RANGE	MAXIMUM READING	ACCURACY (6 months, 20°-30°C) ±(% of rdg + digits)
300mV	299.99	0.2% + 6d*
3 V	2.9999	0.2% + 6d
30 V	29.999	0.2% + 6d
300 V	299.99	0.2% + 6d
1000 V	1000.0	0.2% + 6d

Average responding calibrated in rms of sine wave.
*For readings below 1% of range add 0.15mV.

MAXIMUM ALLOWABLE CONTINUOUS INPUT: 1000V RMS sine or dc, or 10^7 V•Hz.
FREQUENCY RANGE: 50Hz to 20kHz.
TEMPERATURE COEFFICIENT (0° to 20°C and 30° to 50°C): ±(0.025% of reading + 0.5d)/°C.
INPUT IMPEDANCE: 2 megohms shunted by less than 100 picofarads.

AS AN AC AMMETER WITH OPTIONS 1740 AND 1745

RANGE	MAXIMUM READING	ACCURACY (6 months, 20°-30°C) ±(% of rdg + digits)	INPUT VOLTAGE DROP (at full-range)	MAXIMUM ALLOWABLE INPUT
3 μA	2.9999	0.6 % + 60d	0.3 V	2.5mA
30 μA	29.999	0.6 % + 30d	0.3 V	25. mA
300 μA	299.99	0.5 % + 20d	0.3 V	4. A*
3mA	2.9999	0.35% + 20d	0.3 V	4. A*
30mA	29.999	0.35% + 20d	0.3 V	4. A*
300mA	299.99	0.35% + 20d	0.35V	4. A*
3 A	2.9999	0.5 % + 20d	0.7 V	4. A*

*Internally fused at 4A.

FREQUENCY RANGE: 50Hz to 5kHz except 500Hz on 3 μ A range.
TEMPERATURE COEFFICIENT (0° to 20°C and 30° to 50°C): ±(0.03% of reading + 2 digits)/°C.

GENERAL

ZERO STABILITY: Autozeroed to within specified accuracy and temp. coeff. 0°-50°C on 300mV to 1000V ranges. Less than 0.15 μ V/°C on 3mV and 30mV ranges.
DISPLAY: Five .43" LED digits, appropriate decimal position, function and polarity indication.
CONVERSION PERIOD: 320 milliseconds.
OVERLOAD INDICATION: Blinks above ±1200V dc, 1000V ac. Blanks above 29999 counts on all other ranges.
RANGE SELECTION: Automatic and manual on Volts and Ohms. Manual only on Amperes. Voltage and resistance ranges can be selected remotely when the Model 1722 Digital Output/Control accessory is installed. Upranges at 30000, downranges at 02599 when autoranging.

CONNECTORS: Input: Banana Jacks; Analog Output: Amphenol 80PC2F.
ENVIRONMENTAL LIMITS:
Operating: 0°C to 50°C. 0% to 70% relative humidity up to 30°C.
Storage: −25°C to +65°C.
POWER: 90-110, 105-125, 195-235 and 210-250 volts (switch selected), 50-60Hz, 45 V•A max.
ACCESSORIES SUPPLIED: Mating output connector; Model 1746 Low-Thermal Short. One pair low-thermal plugs
ISOLATION: Input LO to power line ground, greater than $10^9\ \Omega$ shunted by less than 0.01μF. Maximum safe input between LO and power line ground 1000V peak.
WARM-UP: One hour to rated accuracy.

DIMENSIONS, WEIGHT: Style M, 90mm (3½ in.) half-rack, overall bench size 100m high x 217mm wide x 385mm deep (4 in. x 8½ in. x 15¼ in.). Net weight, 4,5 kg (10 lbs.).

SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION. The Model 174 Digital Multimeter is a wide-range, general purpose measuring instrument, capable of measuring ac/dc voltage, ac/dc current, and resistance.

1-2. FEATURES.

a. Standard

1. Sensitivity to 0.1 microvolt dc.
2. 30000 count display for high resolution.
3. 0.013% basic dc accuracy
4. Manual, automatic or remote ranging.
5. Lo to CASE isolation to $10^9\Omega$.

b. Optional.

1. Model 1728 Rechargeable Battery Pack.
2. Model 1722 Digital Interface.
3. Model 1723 IEEE Interface.
4. Model 1740 AC Option.
5. Model 1744 Ohmmeter Option.
6. Model 1745 Ammeter Option.

1-3. WARRANTY INFORMATION. The warranty is stated on the inside front cover of the manual. If there is a need for service, contact your Keithley representative or authorized repair facility as given on the inside front cover of this manual.

1-4. CHANGE NOTICE. Improvements or changes to the instrument not incorporated into the manual will be explained on a change notice sheet attached to the inside back cover of the manual.

IMPORTANT

The ⚠ symbol can be found in various places in this Instruction Manual. Carefully read the associated *CAUTION* statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

The ↯ symbol can be found in various places in the Instruction Manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated *WARNING* statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

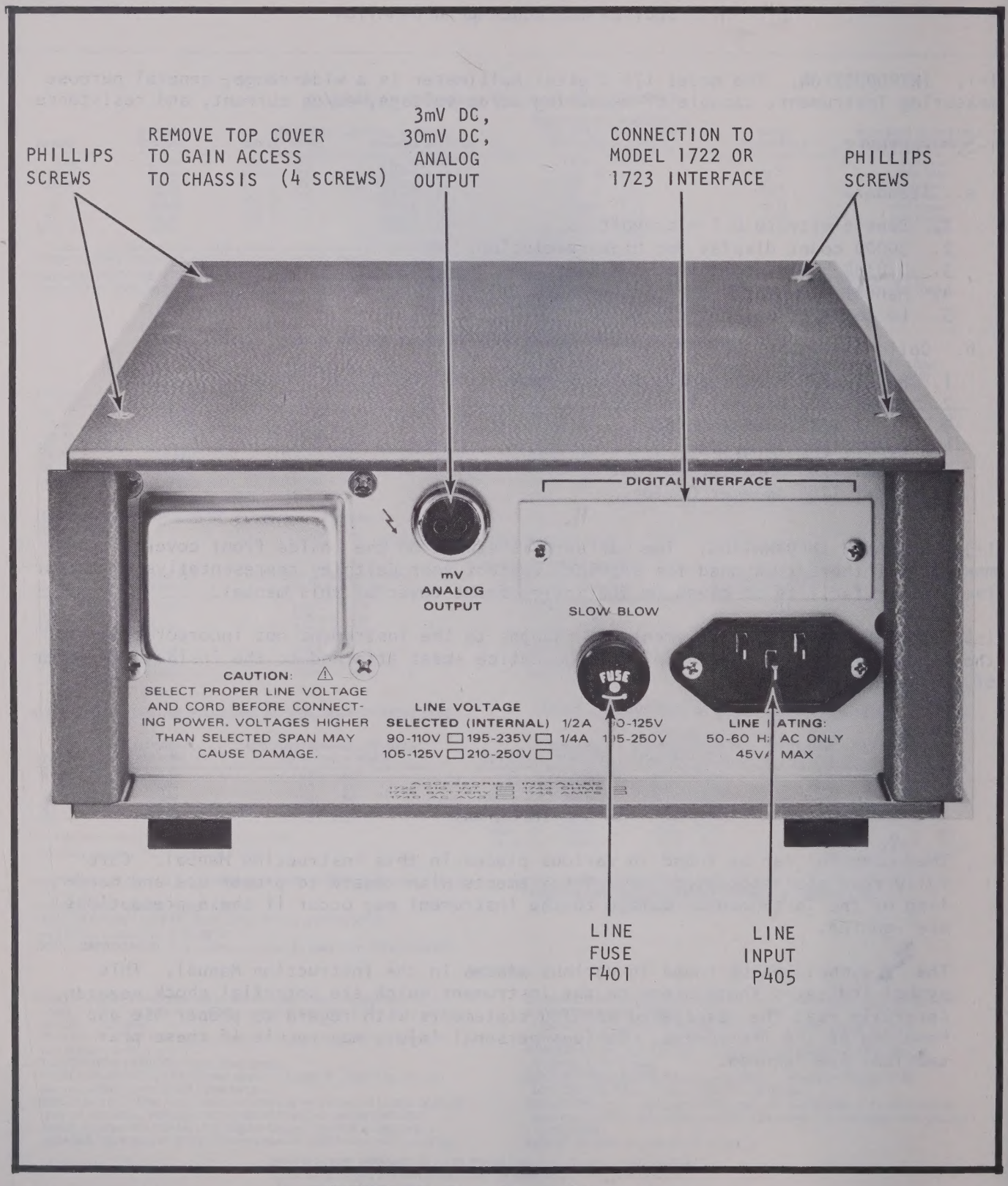


FIGURE 2. Rear Panel Connections.

TABLE 1-1
Summary of Options and Accessories

Options:	Remarks:
Model 1740 AC Option	Factory or Field-Installed. To field-install, refer to Section 2, paragraph 2-3c.
Model 1744 Ohmmeter Option	Factory or Field-Installed. To field-install, refer to Section 2, paragraph 2-3d.
Model 1745 Ammeter Option	Factory or Field-Installed. To field-install, refer to Section 2, paragraph 2-3e.
Supplied Accessories:	
Model 1746A Low-Thermal Short	See ACCESSORIES, Section 4, paragraph 4-7a.
Other Accessories:	
Model 1600 High Voltage Probe	See ACCESSORIES, Section 4, paragraph 4-5a.
Model 1651 50-Ampere Shunt	See ACCESSORIES, Section 4, paragraph 4-5b.
Model 1682 RF Probe	See ACCESSORIES, Section 4, paragraph 4-5c.
Model 1685 Clamp-On AC Current Probe	See ACCESSORIES, Section 4, paragraph 4-5d.
Model 1722 Digital Interface	See ACCESSORIES, Section 4, paragraph 4-3.
Model 1723 IEEE Interface	Described in separate Instruction Manual.
Model 1727 Digital Interface Cable Set	See ACCESSORIES, Section 4, paragraph 4-8.
Model 1728 Rechargeable Battery Pack	See ACCESSORIES, Section 4, paragraph 4-2.
Model 1743 Maintenance Kit	See ACCESSORIES, Section 4, paragraph 4-9.
Model 1747A Low-Thermal Input Leads	See ACCESSORIES, Section 4, paragraph 4-7b.

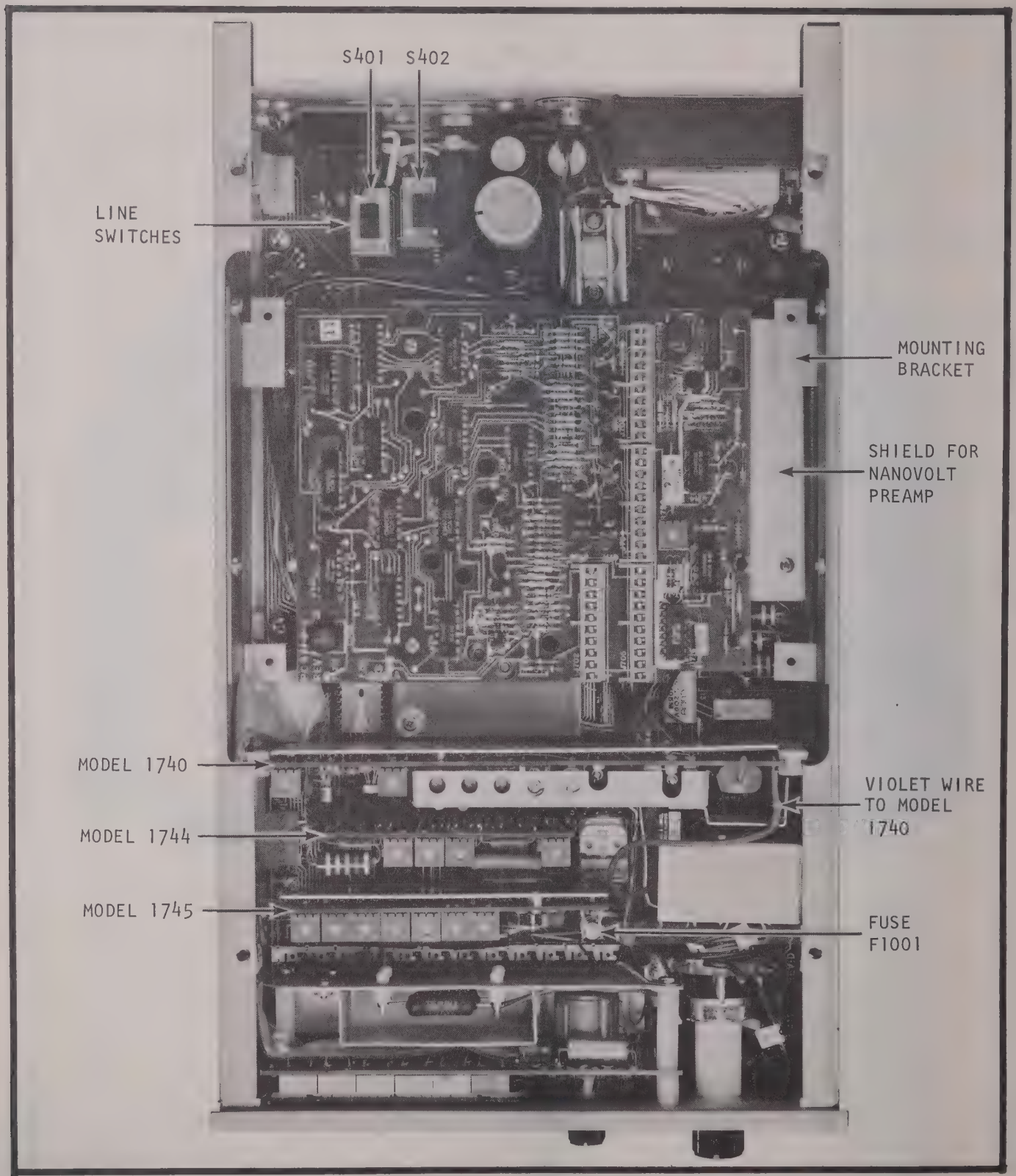


FIGURE 3. View of Chassis With Cover Removed.

SECTION 2. INITIAL PREPARATION.

2-1. GENERAL. This section provides information needed for incoming inspection and preparation for use.

2-2. INSPECTION. The Model 174 was carefully inspected both mechanically and electrical ly before shipment. Upon receiving the instrument, check for any obvious damages which may have occurred during transit. Report any damages to the shipping agent. To verify the electrical specifications, follow the procedures given in Section 6.

2-3. PREPARATION FOR USE. The Model 174 may require some preparation before placing the instrument in use, depending on the field-installable options or accessories to be used. For line operation the Line Voltage switches and Line Fuse should be checked to verify correct settings or value for the line power voltage to be used. If any one of accessory Models 1722, 1723, or 1728 are to be field-installed, the top cover will need to be removed See ACCESSORIES, Section 4 in this manual. If any of the Models 1740, 1744, 1745 Options are to be field-installed, the top cover must be removed and the installation procedures in following paragraphs c, d, and e must be used.

a. How to Set the Internal Line Voltage Switches (S401 and S402). The Model 174 has two slide switches located on the main circuit board as shown in Figure 3. The top cover must be removed to gain access to the circuit board as shown in Figure 2.

WARNING

Disconnect the line cord before removing the top cover of the instrument. Line voltage is present at various points on the circuit board and represents a SHOCK HAZARD.

TABLE 2-1.
Summary of Line Voltage Settings

Switch	Voltage Desired			
	90-110	105-125	190-230	210-250
S 401	LO	NORM	LO	NORM
S 402	117	117	234	234

b. Line Fuse Requirement. The Model 174 uses a single line fuse to protect the line-operated power supply. The fuse is a 3 AB, slow-blow type. Verify that the fuse rating is 1/2A for 90-125V range, 1/4A for 190-250V range. The line fuse is located on the rear panel as shown in Figure 2.

c. How to Install the Model 1740 AC VOLTS Option. Cut the tie wrap holding the "violet" wire. Connect the "violet" input lead (P301) coming from the Function Switch to J1203. Install the plug-in board for the Model 1740 on the Model 174 chassis at P501 and P502 as shown in Figure 4. The plug-in board (PC-414) edges should mate with the teflon card edge guides which support the board. The component side of PC-414 faces the front of the instrument.

IMPORTANT

The AC VOLTS circuit must be calibrated prior to use as in Section 6-4e.

d. How to Install the Model 1744 OHMS Option. The plug-in board (PC-408) for the Model 1744 is installed on the Model 174 chassis at P503 as shown in Figure 4. The component side of PC-408 faces the front of the instrument.

IMPORTANT

The entire 174 Calibration Procedure must be performed prior to use as in Section 6-4.

e. How to Install the Model 1745 AMPERES Option. The plug-in board (PC-409) for the Model 1745 is installed on the Model 174 chassis at P504 and P505 as shown in Figure 4. The component side of PC-409 faces the front of the instrument. Check fuse F1001 for proper rating and condition. Replacement fuse is a Keithley Part No. FU-39; 4 amperes rating.

IMPORTANT

The AMPERES circuit must be calibrated prior to use as in Section 6-4g.

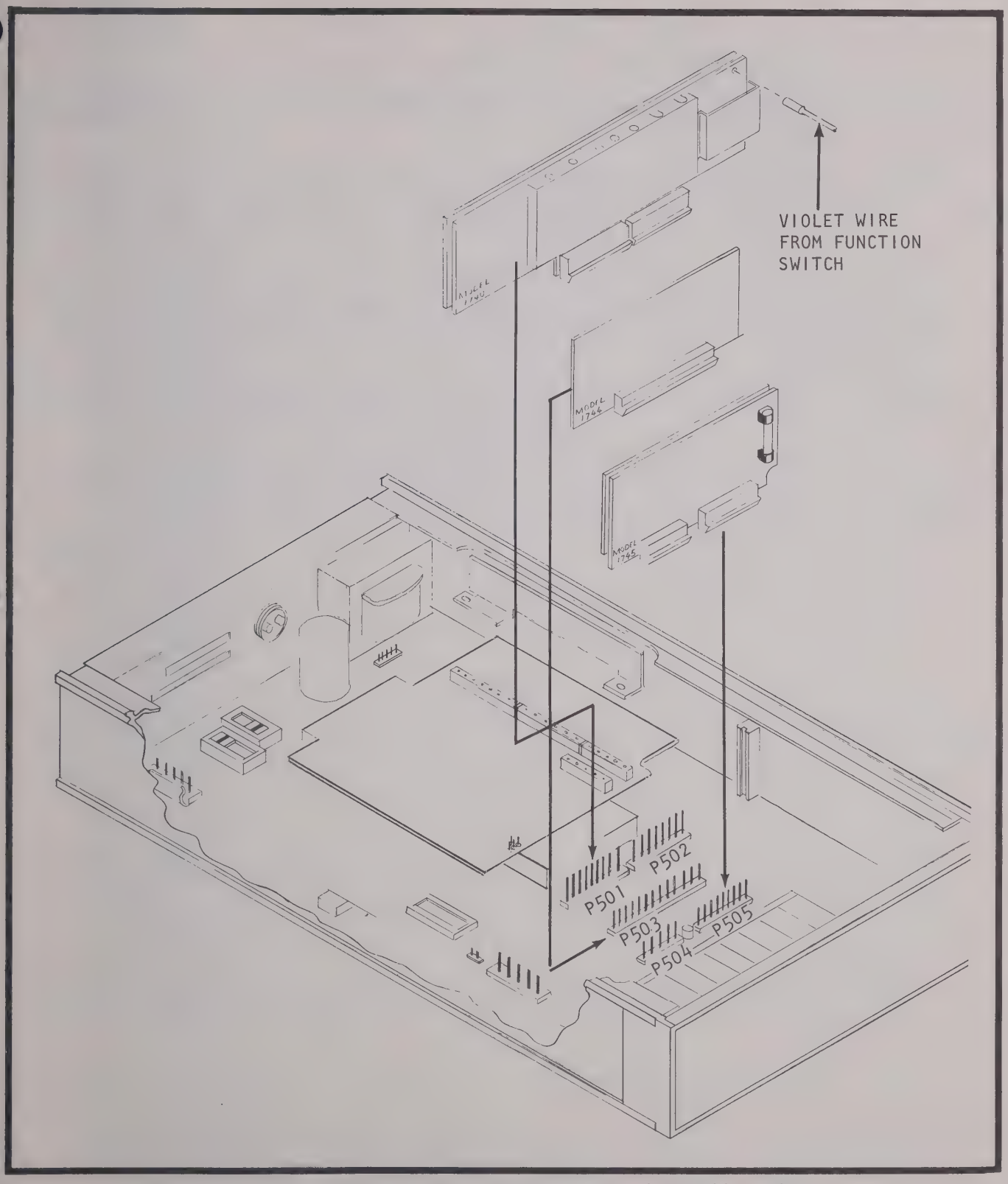


FIGURE 4. Installation of Models 1740, 1744, 1745.

TABLE 2-2.
Summary of Detailed 174 Max Rating at Input Terminals

FUNCTION	HI TO LO MAXIMUM
DC VOLTS	
300 mV - 1 KV	1200V Peak
3 mV and 30 mV	250V RMS sine, ≤60Hz or 250V Peak, $\leq 10^7$V•Hz
AC VOLTS	1000V RMS, $\leq 10^7$V•Hz
OHMS	240V RMS sine, ≤60Hz or 350V Peak, $\leq 10^7$V•Hz
AMPS	
300µA-3A	4A, <250V PK or ≤60Hz RMS if fuse blows
30µA	25mA or 250V RMS on fixed range
3µA	2.5mA or 250V RMS on fixed range

SECTION 3. OPERATING INSTRUCTIONS.

3-1. GENERAL. This section provides information needed to operate the Model 174 for measurement of voltage, current, and resistance, when the appropriate option is installed.

3-2. HOW TO SELECT POWER. The Model 174 may be powered from line voltage or rechargeable nickel-cadmium batteries. The Model 1728 must be installed to permit battery operation. The line-voltage supply is built-in. The power cord is detachable and is 6 feet (2 m) long.

NOTE

The accessory Model 1728 Rechargeable Battery Pack may be ordered at the time of purchase of the Model 174 or may be purchased and field-installed at a later time if so desired.

a. How to Operate From Line Power. The Model 174 can be powered from line voltage over four ranges, from a minimum of 90 V rms to a maximum of 250 V rms. Table 2-1 (pg 2-1) summarizes the line voltages permitted.

1. Set the internal line voltage switches (S401 and S402) to the appropriate position as described in Section 2, paragraph 2-3a.
2. Attach the line cord (CO-7) to the Model 174 at power input receptacle (P405) on the rear panel. If a shorter line cord is desired, order Keithley Model 7003 Power Cord (2 foot long).
3. Check the line fuse for proper rating as described in Section 2, paragraph 2-3.
4. Plug the line cord into a source of line power.
5. Depress LINE pushbutton.

NOTE

Power on will be indicated by a lighted display with one or more digits and measurement units showing.

b. How To Operate From Battery Power.

1. Install the Model 1728 Rechargeable Battery Pack. (See Section 4, paragraph 4-2.)
2. Depress BAT pushbutton.
3. If the LOW BAT indicator is lighted in BAT mode, refer to Section 4-2c for recharging; otherwise, the Model 174 may be used for measurements.

NOTE

The Model 1728 is shipped from the factory in uncharged condition. Therefore, the Model 1728 should be installed and charged prior to use. After the Model 1728 has been charged for at least 16 hours, the Model 174 can be powered continuously for at least 3 hours.

TABLE 3-2.
Summary of Operation in Line and Bat Modes

Button Depressed	Condition of Instrument		
	Line Power Connected 1728 Not Installed	Line Power Connected 1728 Installed	Line Power Not Connected 1728 Installed
LINE	ON	ON Battery trickle charged.	OFF
BAT	OFF	ON Battery slowly discharged.	ON
NEITHER LINE NOR BAT	OFF	OFF Battery charged at maximum rate.	OFF

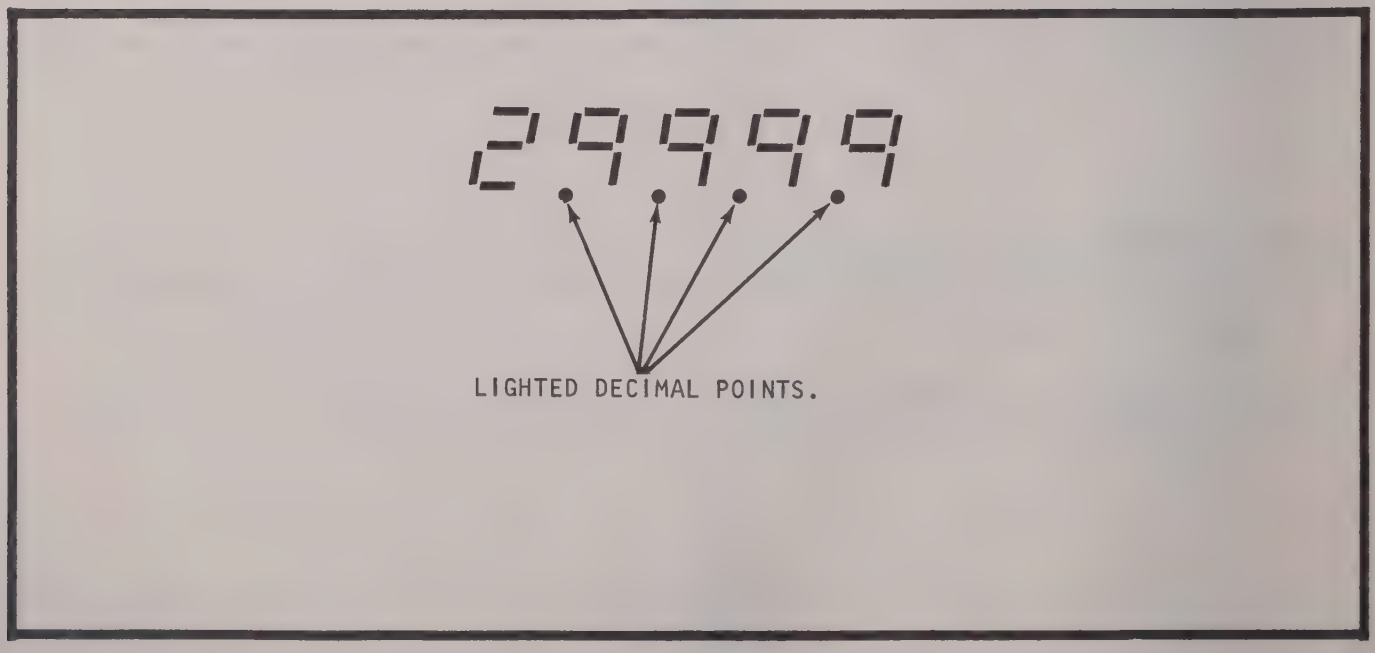


FIGURE 5. Typical Display For Non-Valid Function.

3-3. HOW TO SELECT FUNCTION. Function is selected by means of a front panel rotary switch (S302).

a. V AC (∿). When the Function Switch is set to V AC the Model 174 will be set to ac voltage function. Refer to paragraph 3-6 for operating information.

IMPORTANT

The Model 174 can be used to measure ac voltage only when the Averaging AC Voltage Option 1740 is installed. If this option is not installed the Model 174 will display all four decimal points to indicate a non-valid function as shown in Figure 5.

b. V DC ($\overline{---}$). When the Function Switch is to V DC the Model 174 will be set to dc voltage function. Refer to paragraph 3-6 for operating information.

c. Ohms (Ω). When the Function Switch is set to HIΩ or LOΩ the Model 174 will be set to resistance (ohms) function. Refer to paragraph 3-6 for operating information.

IMPORTANT

The Model 174 can be used to measure resistance only when the Ohmmeter Option 1744 is installed. If this option is not installed, the Model 174 will display all four decimal points to indicate a non-valid function as shown in Figure 5.

1. HIΩ. When the FUNCTION Switch is set to HIΩ, the Model 174 permits resistance measurements in 6 ranges from 3KΩ to 300MΩ. Full range voltage is 3 V.

2. LOΩ. When the FUNCTION Switch is set to LOΩ, the Model 174 permits resistance measurements in 6 ranges from 300Ω to 30MΩ. Full range voltage is 300 mV.

d. A DC ($\overline{---}$). When the FUNCTION Switch is set to A DC the Model 174 will be set to dc current function. Refer to paragraph 3-7 for operating information. Neither autoranging nor remote ranging are available on Amperes.

IMPORTANT

The Model 174 can be used to measure dc current only when the DC Ammeter Option 1745 is installed. If this option is not installed the Model 174 will display all four decimal points to indicate a non-valid function as shown in Figure 5.

e. A AC (∿). When the FUNCTION Switch is set to A AC the Model 174 will be set to ac current function. Refer to paragraph 3-7 for operating information. Neither autoranging nor remote ranging are available on Amperes.

IMPORTANT

The Model 174 can be used to measure ac current only when both the AC Voltage Option 1740 and the DC Ammeter Option 1745 are installed. If these options are not installed the Model 174 will display all four decimal points to indicate a non-valid function as shown in Figure 5.

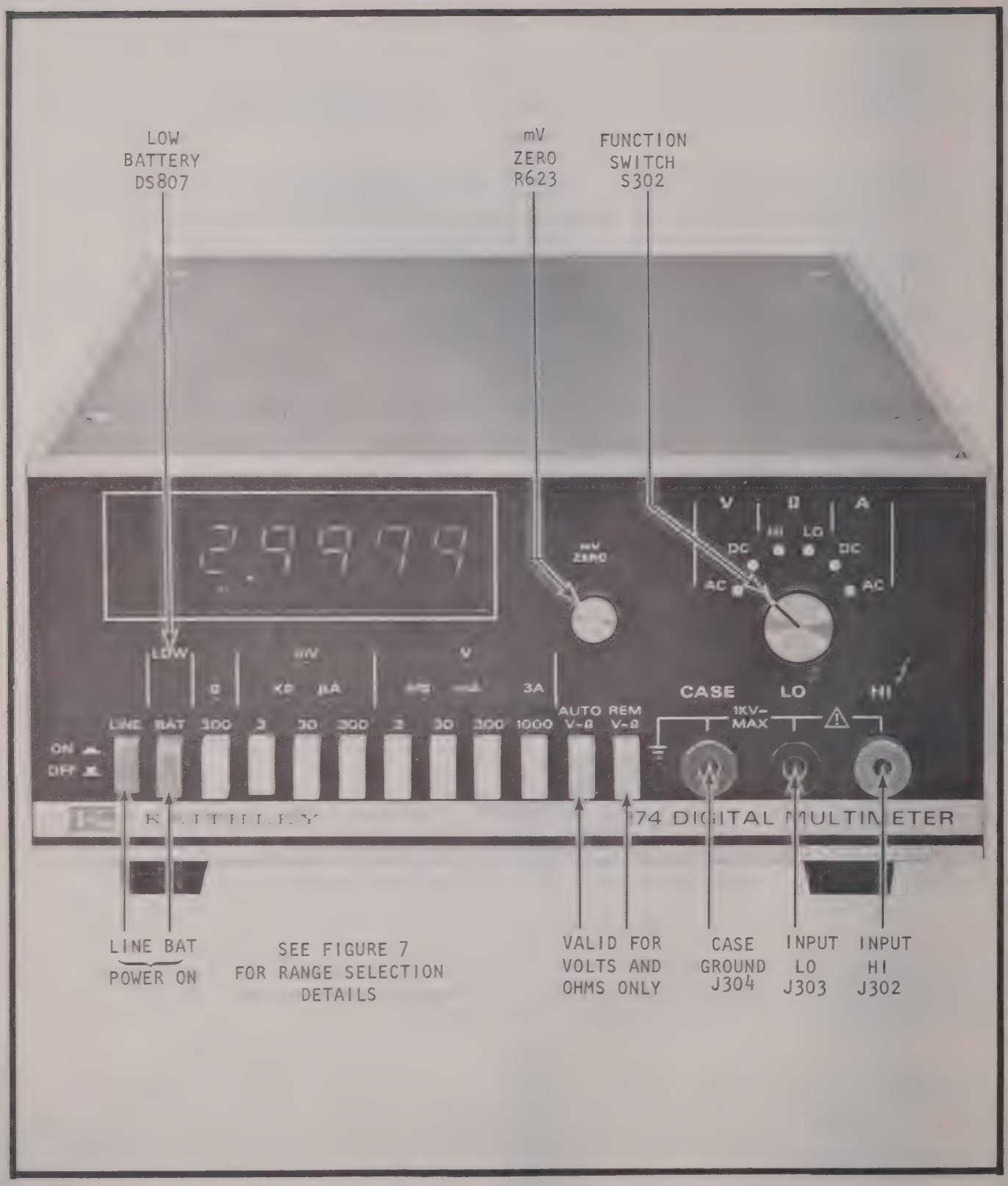


FIGURE 6. Front Panel Controls and Input Terminals.

3-4. HOW TO SELECT RANGE. On VAC, VDC, and Ω the Model 174 provides automatic, remote, or manual ranging. Remote ranging is available only when the Model 1722 or 1723 is installed.

a. Manual Ranging. (All functions). The Model 174 can be set to Manual Mode by depressing the appropriate range pushbutton. See Figure 7 for detailed explanation of manual ranging.

NOTE

If A AC or A DC is selected and none of the valid current range pushbuttons are depressed the Model 174 will be placed in the following condition: The input resistance will be 100 KΩ in parallel with overcurrent protection diodes. The Model 174 display will read near zero (independent of the signal applied) and the decimal position will be the same as for the 3 µA range (0.0000).

b. Remote Ranging. (V AC, V DC, and OHMS only). Remote ranging is available only when the Model 1722 or Model 1723 is installed and the REM pushbutton is depressed. Refer to Section 4 ACCESSORIES for information regarding Models 1722 or 1723.

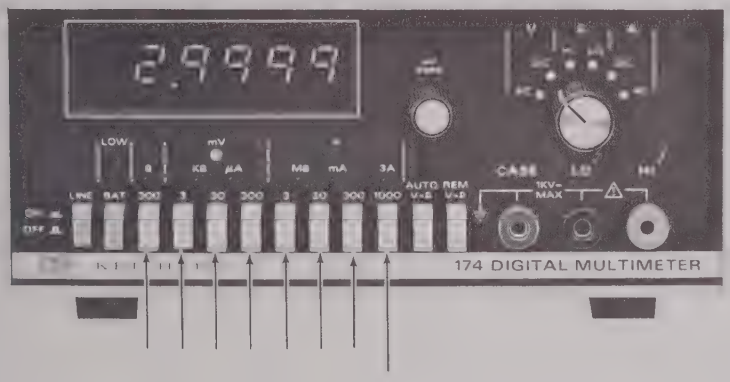
NOTE

The REM pushbutton determines range control only, and does not affect timing controls, Trigger, Hold, and Trigger Mode.

c. Autoranging. (V AC, V DC, and OHMS only). The Model 174 will be placed in Autoranging mode under the following conditions.

1. If AUTO is depressed the Model 174 will be set to autoranging mode.

2. If none of the manual range nor REM pushbuttons are depressed (that is, all are released), then the Model 174 will be set to autoranging mode as a default condition.



MANUAL RANGE OPERATION:

The pushbuttons are arranged in three sections: 300Ω; mV, KΩ, µA; V, MΩ, mA, 3A. Individual annunciators identify each section. For example, if the "300" pushbutton within the mV, KΩ, µA section is depressed the Model 174 will be set to 300 mV DC if DC V function has been selected. (300 mV AC, 300 KΩ, or 300 µA for other functions.)

NOTE

Some pushbuttons are intended for range selection only on certain functions (e.g. 300 Ω).

When a pushbutton is depressed which requests a range which is "not available" on the selected function (e.g. 3mV on VAC), the Model 174 goes to the nearest available higher range (300mV in this instance). The annunciator will always indicate a correct reading for the selected range.

FIGURE 7. Manual Ranging on the Model 174.

NOTE

The following rules govern the autoranging feature:

a) When the display exceeds 29999, the Model 174 upranges (that is, it changes to less sensitivity and the decimal point and measuring unit changes appropriately).

b) When the display reaches 02599 the Model 174 downranges (that is, it changes to greater sensitivity and the decimal point and measuring unit changes appropriately) until it reaches the most sensitive range (except 3mV dc and 30 mV dc).

3-5. HOW TO MEASURE VOLTAGE. The Model 174 measures dc voltage in seven ranges: 3mV, 30mV, 300mV, 3V, 30V, 300V, and 1000V DC. When the Model 1740 Option is installed, the Model 174 measures ac voltage in five ranges, 300 mV, 3V, 30V, 300V, and 1000V.

CAUTION

Maximum input voltage depends on the range selected. Table 3-3 gives the maximum allowable continous input for each range on AC and DC. Do not exceed these voltages or damage to the instrument will occur.

TABLE 3-3.
Maximum Allowable Continuous Input

Range	AC Voltage (ACV)	DC Voltage (DCV)
3mV	*	250V Peak
30mV	*	250V Peak
300mV	1000V rms ($<10^7$V•Hz)	1200V Peak
3 V	1000V rms ($<10^7$V•Hz)	1200V Peak
30 V	1000V rms ($<10^7$V•Hz)	1200V Peak
300 V	1000V rms ($<10^7$V•Hz)	1200V Peak
1000 V	1000V rms ($<10^7$V•Hz)	1200V Peak

*NOTE

When 3mV or 30mV range pushbuttons are depressed, the 300mV range will be selected and thus the allowable input will be 1000 V rms ($<10^7$V•Hz).

a. DC Voltage. The Model 174 detects dc voltages from ±0.1 microvolts/digit to ±1200 volts (1200.0 display). The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked. The display blinks above 1200.0 volts on the highest range.

1. Select V DC on Switch S302.

2. Depress AUTO, REM or desired Manual Range pushbutton.

3. Connect the signal to be measured between HI and LO terminals. The terminals are designed to accept banana or "bunch pin" plugs, such as the accessory Keithley Model 1747 Low-Thermal coaxial input cable. These leads are recommended for measurements below 10 microvolts dc resolution.

4. Observe the displayed digits, polarity sign, decimal point location, and measurement unit (mV or V). If no polarity sign is indicated, a positive polarity is implied. A "zero" reading will always be displayed as -.0000.

5. On the 3 mV and 30 mV DC ranges the front panel "mV ZERO" control must be adjusted to obtain rated accuracy.

a) Make low-thermal connections to the Model 174 as described above. Use of the Model 1747 cable or satisfactory equivalent is recommended.

b) Set the Model 174 to the 3 mV range.

c) Allow the thermal emfs generated by the input connections to stabilize.

d) Some circuits may need to be enclosed in polyurethane foam, a cardboard box, or other suitable enclosure to prevent zero fluctuations due to air movement at the connection point.

e) Make certain that a "Zero Signal" condition is established for the circuit to be measured (e.g., a zero current condition for a resistance thermometer measurement).

f) Adjust the "mV ZERO" control for a display indication of -.0000 mV ± .0001 mV.

NOTE

The "mV ZERO" control operates only on the 3 mV DC and 30 mV DC ranges. It has no effect on any other range or function.

g) Proceed with the measurement and apply the signal.

h) The "mV ZERO" control setting will also be valid for the 30 mV range if used.

b. AC Voltage. The Model 174 detects ac voltages from 10 microvolts to 1000 volts (1000.0 display). The Model 174 is average-reading, calibrated in terms of rms sinewave. The Maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked. The display blinks above 1000.0 volts on the highest range. Maximum input voltage is 1000 V rms or 10^7 V•Hz on all ranges.

1. Select V ac on Switch S302.

2. Depress AUTO, REM or desired Manual Range pushbutton.

3. Connect the signals to be measured between HI and LO terminals. (The terminals are designed to accept banana or "bunch pin" plugs, such as the accessor Keithley Model 1747 Low-Thermal coaxial input cable.

4. Observe the displayed digits, decimal point location, and measurement unit (mV or V).

3-6. HOW TO MEASURE RESISTANCE. When the Model 1744 Option is installed, the Model 174 measures resistance from 10 milliohms/digit to 300 megohms. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked. Maximum allowable input voltage is 240V rms or 350 V peak up to 60 Hz.

a. HI Ohms Measurement. When Switch S302 is set to HIΩ, the voltage developed across the resistance under test at full range is 3 volts. The Model 174 measures from 3KΩ to 300 megohms full range in HI mode.

1. Select HIΩ on Switch S302.
2. Connect the resistance under test between HI and LO terminals.
3. Depress AUTO, REM, or the desired Manual Range pushbutton.
4. Observe the displayed digits, decimal point location, and measurement unit (KΩ or MΩ).

b. LO Ohms Measurement. When Switch S302 is set to LOΩ, the voltage developed across the resistance under test at full range is 300 millivolts. The Model 174 measures from 300Ω to 30 megohms full range in LO Mode.

1. Select LO Ω on Switch S302.
2. Connect the resistance under test between HI and LO terminals.
3. Depress AUTO, REM, or the desired Manual Range pushbutton.
4. Observe the displayed digits, decimal point location, and measurement unit (Ω, KΩ, or MΩ).

c. Lead Resistance Compensation. The Model 174 measures the total resistance between HI and LO terminals. For measurement on low resistance ranges where lead resistance may cause an error the following procedure should be performed.

1. Connect the measuring circuit to the INPUT terminals on the 174 using appropriate test leads or cables.
2. Substitute a temporary short circuit in place of the circuit to be measured.
3. In the case of the Model 1747, temporarily clip together the alligator connectors.
4. Record the reading on the Model 174 as R_0 (residual lead resistance under a shorted condition).
5. Remove the shorted condition and connect the active circuit to be measured.
6. Record the new reading in the Model 174 as R_x.
7. The true value of "R_x" is $R_T = R_x - R_0$, within the stated accuracy of the Model 174. No additional errors in the resistance measurement are added when using this method.

3-7. HOW TO MEASURE CURRENT. When the Model 1745 option is installed, the Model 174 measures dc current in seven ranges: 3μA, 30μA, 300μA, 3mA, 30mA, 300mA, and 3A. When both the Model 1740 and 1745 Options are installed, the Model 174 measures ac current over the same ranges. Range selection is via manual range pushbuttons only.

CAUTION

The Model 174 DMM is protected by a 4 ampere fuse on all ranges except 3μA and 30μA. On the 3μA and 30μA ranges the maximum allowable input corresponds to a 250V input voltage. If the fuse is blown, a replacement Keithley Part No. FU-39 should be installed in the fuse holder on the 1745 option. Refer to Section 6, MAINTENANCE, Paragraph 6-5, for fuse replacement.

a. DC Current. The Model 174 DMM detects dc currents from ±0.1 nanoamperes to ±3 amperes. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted but all other digits are blanked.

1. Select A dc on Switch S302.
2. Depress the desired Manual Range pushbutton.
3. Connect the signal to be measured at the HI and LO terminals.
4. Observe the displayed digits, polarity sign, decimal point location, and measurement unit (μA, mA, or A). If no polarity sign is indicated, a positive polarity is implied. A "zero" reading will always be displayed as -.0000.

b. AC Current. The Model 174 DMM detects ac currents from 0.1 nanoamperes/digit to 3 amperes in AC function. The Model 174 is average reading calibrated in rms of a sine wave. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked.

1. Select A AC on Switch S302.
2. Depress the desired Manual Range pushbutton.
3. Connect the signal to be measured at the HI and LO terminals.
4. Observe the displayed digits, decimal point location, and measurement unit (μA, ma or A).

3-8. FURTHER MEASUREMENT CONSIDERATIONS.

a. Grounding Considerations. The CASE terminal and the third wire ground on the line cord are provided to avoid electrical shock in the event of an electrical malfunction. The ground (CASE) terminal, when properly connected to a reliable ground, serves as a return current path and ensures that the instrument chassis ground is at a safe potential at all times.

WARNING

Always ensure that the instrument is grounded either through the third wire on the line cord or through a separate connection between CASE terminal and reliable earth ground. Failure to follow these precautions could result in serious personal injury due to electrical shock.

b. How to Use the Model 174 Off-Ground. The "LO" terminal can be operated off ground at potentials of up to ±1000 volts. Isolation from the "LO" terminal to power line ground (CASE terminal) is specified at $10^9\Omega$ shunted by less than 0.01μF. In general, the LO terminal should be connected to the point in the measurement circuit which has the lowest impedance to power line ground or the "effective guard" or "shield" mode in the circuit. If the measurement circuit is independent of power line ground LO and CASE should be connected to a common point in the circuit.

c. 3mV/30mV Accuracy. The 3mV/30mV accuracy specifications assume that the instrument has been in thermal equilibrium with the environment for 1 hour or more, and that the front panel "mV ZERO" control has been used immediately prior to the measurement to obtain a "zero" indication of -.0000 mV ± .0001 mV. The "mV Zero" control is used in this manner to compensate for thermal emfs generated in the circuits connected to the input terminals. These externally generated thermal emfs must remain constant during the measurement in order to obtain stated accuracy.

d. 300mV Accuracy. The 300mV accuracy is given down to 1% of range. Below 1% of range an additional .15mV is added to the accuracy. This does not occur immediately at the 1% level, but gradually as the level is decreased below 300μV.

e. mV Analog Output. This output is active only on 3mV and 30mV ranges. No accuracy is specified. Typically the output is within ± (2 x accuracy spec + digit). On other ranges and functions output voltages up to ±15V may exist. Output may be randomly varying within this span, or have step changes within this span. Notice that the "mV Analog Output" point is the output of the nanovolt preamp, which has a fixed gain of 100, and no switching is done, except in the A/D converter between 3mV and 30mV ranges. Thus, the "mV Analog Output" provides continous X100 output for signal levels as low as the Model 174 noise level (typically 100nV to 150nV p-p, up to 30mV).

f. Overload on 3mVdc and 30mVdc. Up to 250V may be continuously applied at frequencies from DC up to 60Hz. Up to 180V RMS may be applied continuously at any frequency up to 10^7V • Hz product. When switching from 3mV/30mV to higher ranges the voltage must not exceed the overload specification on the 3mV/30mV ranges until 10 ms after the range change command is given. (e.g. 10ms after Load Range goes active or a new range push-button is depressed).

g. Offset Current. The offset current is adjusted to 10pA at the factory or by executing the calibration procedure given in Section 6-4. Offset current will change with time and temperature, but is is unlikely to exceed 200pA at any environment within the specified region up to 6 months after calibration. Short term variations are such that peak-to-peak noise in the Model 174 will be larger (than that exhibited with a short circuit) for source resistances in excess of about 30KΩ to 70KΩ.

h. Settling Time. Table 3-4 gives typical and worst expected settling times expressed as the number of conversions (320 ms) for the Model 174. The numbers in the table assume that the proper range and function have been selected and previous transients have "settled" before a "step change" in the signal is applied. The numbers do not include effects of input cabling time constants.

TABLE 3-4.

Function	Range	Source R	Number of Conversions Required to Settle to Within 0.01% of a "Step Change".	
			Typical	Worst Expected
DCV	3mV, 30mV	≤10KΩ	3	6
	3mV, 30mV	100KΩ	10	13
OHMS	All except 300MΩ HI 30MΩ LO	≤End Range	3	6
OHMS	300MΩ HI 30MΩ LO	End Range	10	20
DC AMPS	All	Any	3	6
AC VOLTS	All	≤100KΩ	4	8
AC AMPS	All	Any	4	8

A particular Model 174 will have repeatable settling time characteristics for a fixed (or low) source resistance. The above is a rough indication of what can be expected of most instruments ("typical values") and the maximum settling time of a "slow" but properly operating instrument ("worst expected values").

SECTION 4. ACCESSORIES

4-1. GENERAL. This section describes various accessories available for use with the Model 174. These accessories include the Model 1728 Rechargeable Battery Pack, the Model 1722 Digital Interface, the Model 1723 IEEE Interface, rack mounting kits and various probes, test leads, and other convenience accessories. Model 1722, 1723 and 1728 can only be installed and used one at a time.

NOTE

Models 1740, 1744, and 1745 are field-installable options which are described in Section 2 INITIAL PREPARATION and Section 3 OPERATING INSTRUCTIONS.

4-2. MODEL 1728 RECHARGEABLE BATTERY PACK. The Model 1728 powers the 174 for portable use, or for complete freedom from ac power lines for critical measurements where near-infinite commonmode rejection is needed. A front panel low-battery indicator shown when recharging is needed from the built-in charger. Ni-Cd rechargeable batteries give 3 hours operation from full charge. The Model 1728 recharges completely in 16 hours with instrument off. Trickle charges with instrument on. The Model 1728 is field installable with screwdriver and adds 1,4 kg (3 pounds) to 174. Storage and ambient operating temperatures: -25°C to +35°C when installed in the Model 174.

*NOTE: Model 1722, 1723 and 1728 can only be installed and used one at a time.

NOTE

The Model 1728 Rechargeable Battery Pack can be installed by the user within the Model 174 at any time. However, if the Model 1722 Digital Interface or the Model 1723 IEEE Interface is already installed, the Model 1728 cannot be used simultaneously.

a. How to Install the Model 1728 Rechargeable Battery Pack. The batteries furnished with the Model 1728 are already installed in the battery pack. The battery pack includes 7 rechargeable "C" cells (1.2V, 2 AMP Hr) and two 19.2 volt packs (sixteen 1.2V cells per pack). See Figure 8.

1. Check the fuses on the Battery Pack. Three fuses are used, F401, F402, and F403. All are 1 ampere, 3AB or 3AG, Slo-Blo types, Keithley Part No. FU-10.

2. Check for proper installation of batteries in the Battery Pack. If replacement battery cells are to be installed see paragraph 4-2d.

3. To install the Battery Pack, loosen four Phillips screws on the top cover as shown in Figure 2. Carefully remove the top cover to gain access to the printed circuit board. Temporarily remove the plastic spacers installed on the Model 174 chassis. Separate the two halves of the spacer and reinstall on the Model 1728 board as shown in Figure 9. The rubber "O" ring retains the spacer and screw assembly. Plug the two 5-wire connectors (J401, J402) into the mating receptacles (P401, P402) taking care to orient the connectors as shown. If the Model 1740 AC Option is installed, it will be necessary to temporarily remove the 1740 pc board to permit access to connector P401 as in Figure 9. Place the Model 1728 in position on the spacers with the pack oriented as shown in Figure 9 and tighten down the four screws which hold the Model 1728 to the Model 174 chassis. Replace the top cover and tighten down the four Phillips screws.

b. How to Check Batteries.

IMPORTANT

The Model 1728 is shipped from the factory in an uncharged condition. Therefore, the pack should be installed in the Model 174 and charged prior to use.

1. The Model 174 has a built-in LOW BAT indicator to permit easy determination of battery condition.

2. The LOW BAT indicator will be lighted when the Battery Pack goes below normal operating voltage. When the indicator turns on, the Model 174 should be switched to LINE or OFF to permit recharging of the Pack.

c. How to Charge the Batteries. The Model 1728 provides built-in recharging circuitry. The Model 174 must be connected to line voltage. Recharging occurs at the most rapid rate when the Model 174 is set to OFF.

CAUTION

Overcharging the batteries will raise the internal temperature of the battery pack and may shorten the life of the batteries.

d. How to Replace Batteries. The rechargeable batteries will normally provide many rechargings before replacement is necessary. However, if it is necessary to replace the batteries, use only the equivalent types as supplied by the factory. Table 4-1 summarizes the batteries used in the Model 1728.

TABLE 4-1.
Summary of Batteries Used in the Model 1728.

Description	Quantity	Voltage	Keithley Part No.
1.2V "C" cell (2 AMP-HR)	7	8.4V	BA-30
+19.2V pack (16-1.2V cells)	1	+19.2V	BA-31
-19.2V pack (16-1.2V cells)	1	-19.2V	BA-31

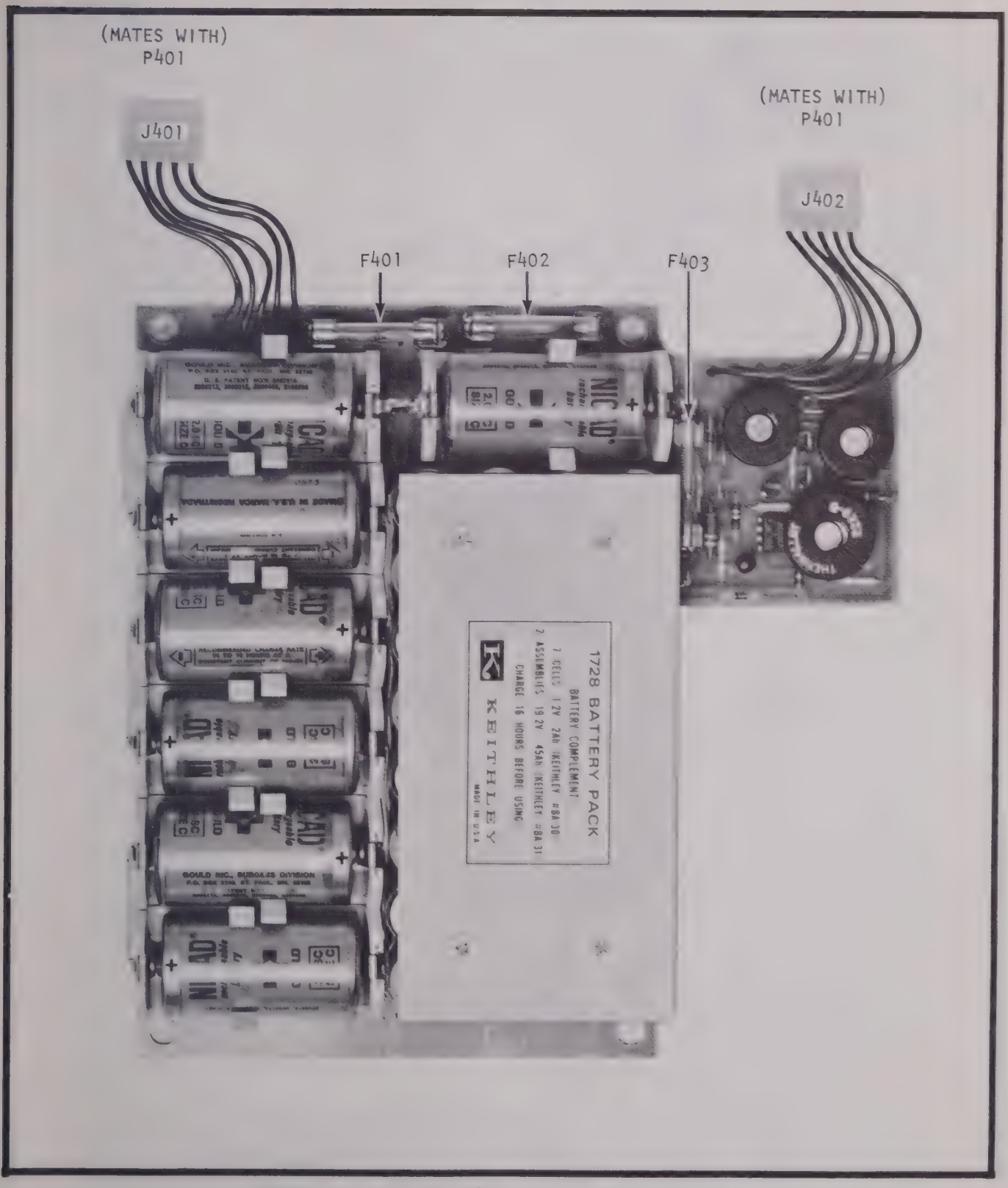


FIGURE 8. Model 1728 Rechargeable Battery Pack.

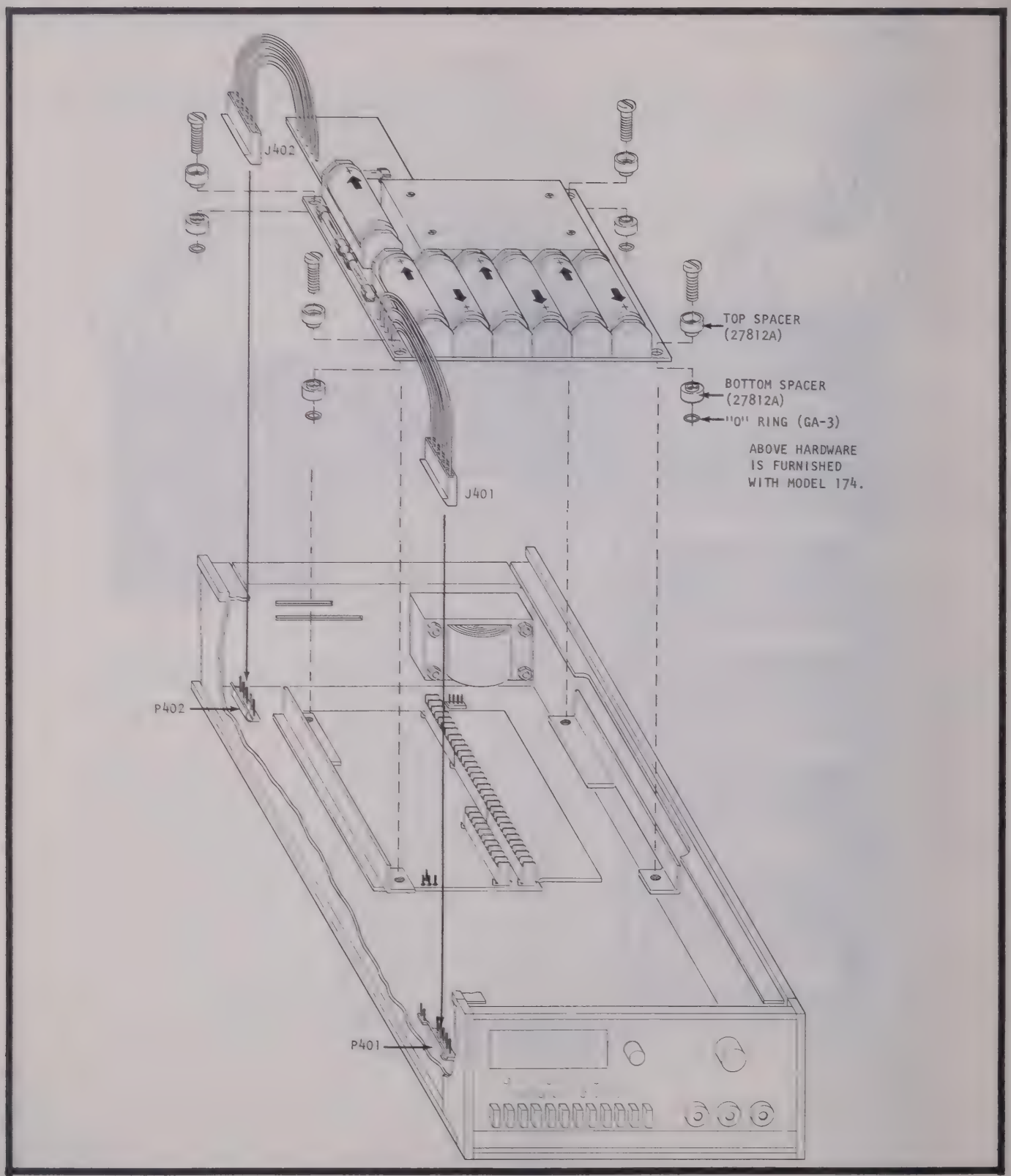


FIGURE 9. Installation of Model 1728.

e. Circuit Description. (See also Schematic 26758C.)

1. The Model 1728 provides ±19.2 volts and +8.4 volts from nickel-cadimum batteries. BT401 and BT402 are 19.2 volt, .45 AH nickel cadmimum packs which are fused by 1A, 3AG Slo-Blo fuses. BT403 is an 8.4V pack composed of seven 1.2 volt "C" cells and is also fused by a 1A, 3AG, Slo-Blo fuse. The Model 1728 has a built-in recharging circuit which is operated from ±29.5V unregulated supplied by the DMM line-power supply.

2. BT401 Charging. BT401 is charged via a constant current from Q401. Diodes CR401 and CR402 and resistor R402 place a diode drop across R401. The resulting current is the maximum charging current. Diode CR403 prevents the battery from supplying current through Q401. The maximum charging current occurs only when the DMM is set to OFF. A trickle charge is maintained when the DMM is line operated. The reduced current is obtained by inserting a limiting resistor in series with the charging circuit (not shown on Schematic 26758C). In full charge, the batteries are charged at a C/10 rate (45 mA for BT401 & BT402, & 200mA for BT403). When trickle charged, the charge rate varies according to line voltage & battery condition from a minimum of C/100 rate to a maximum of C/20 rate. Thus, trickle charge may never fully charge the batteries, but is intended to put sufficient charge into them for short intermittent use.

3. BT402 & BT403 Charging. BT402 & BT403 are charged via a constant current from Q402 or Q401 respectively. These circuits operate similarly to the above circuit, except that they are powered by unregulated ±29.5V.

4-3. MODEL 1722 DIGITAL INTERFACE.

a. General. The Model 1722 provides binary coded decimal outputs (8421) and range control lines. Outputs are open-collector positive true unless otherwise specified. This accessory is available either "factory installed" or "field-installable". The Model 1722 consists of a two-layer circuit with card-edge and mating output connectors.

b. Installation.

1. Disconnect the Model 174 line cord from line voltage.
2. Depress LINE pushbutton to discharge any voltages on power supply capacitors, etc.
3. Loosen and remove the four Phillips screws on the top cover as shown in Figure 2.
4. Lift off the top cover and set aside.
5. Temporarily remove the four spacer assemblies held down by a slotted screw.
6. Reassemble the spacers as shown in Figure 10. Be careful to install the "O" ring over the screw to hold the assembly together prior to installing the Model 1722 board.
7. Place the Model 1722 in the location shown in Figure 10 with the cables oriented properly. See detailed view for orientation of connectors.
8. Plug the Model 1722 connectors J1003, J1001, and J1002 into mating connectors P403, P404, and P701 respectively. See detailed view for orientation of connectors.
9. Connect the ground return wire from the Model 1722 to the screw on transformer T401 as shown in Figure 10.
10. Reinstall the top cover.

c. Digital Output Connector Terminations. The Model 1722 uses two card-edge connectors P1006 (40-pin) and P1101 (26-pin). Accessory Model 1727-03 (3 ft. long) or Model 1727-10 (10-ft. long) cables mate with P1006/P1101 connectors. See Figure 11 for pin identification.

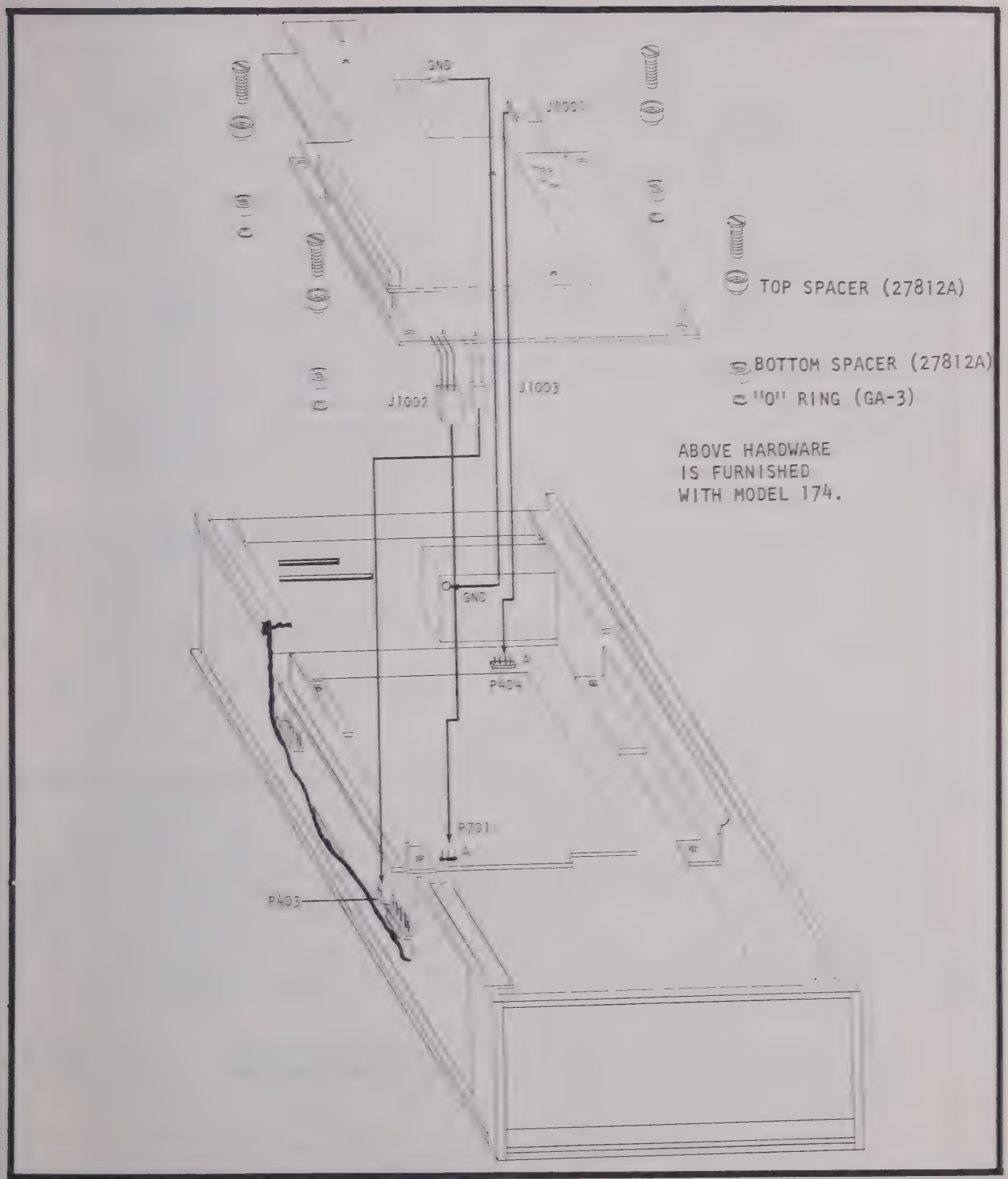


FIGURE 10. Installation of Model 1722 Digital Interface.

TABLE 4-2.
General Characteristics of Model 1722 Digital Interface.

DIGITAL OUTPUTS:
Logic: BCD (8421) Open-collector positive true unless otherwise specified.
Data: 4 full digits, 1 partial digit (0, 1, 2, 3) and exponential range code.

Function: 4-bit code (Ω, AC VOLTS)
Polarity: HIGH ≡ +.
Overflow: LOW ≡ > 29999.
Autorange: LOW ≡ range change.
Automode: HIGH ≡ autorange mode.

FLAG ($\overline{\text{FLAG}}$): HIGH (logic "0" ≡ no output change occuring.)
Logic Levels: HIGH ≡ open collector to output LO. LOW ≡ closure to output LO. Output device (2N5134) greater than 20V breakdown, <0.5V at 5mA sink (3TTl loads). Internal pull-up resistors may be installed on these open collector outputs. 4.7K minimum value is recommended when using internal 5 volt power supply.

OUTPUT TIMING: Data is updated typically every 320 msec (non-trigger mode). Update time is typically 1.2 msec. Data will appear at an output only if its respective strobe is active. The FLAG will go low (Logic "0") typically 2 msec before update and go high typically 100 µsec after update. Data can be expected to be unchanging so long as the flag is high. If FLAG RESET is activated, the FLAG will reset (go to Logic "0") until the end of the next data update.

REMOTE CONTROLS:
Strobe: Strobe lines permit word serializing in 4-bit increments or multiples thereof. HIGH inhibits controlled output lines from conduction, LOW enables conduction.
Range In: 4-bit exponential code.
Load Range: Low enables remote ranging as set by Range code.
Hold: LOW inhibits display update, output update and autorange (A/D continues conversions).
Printer Hold: Same as hold but grouped with outputs for convenience in interfacing printer.
Trigger Mode: LOW enables TRIGGER control.
Trigger Mode Disable: LOW disables TRIGGER.
Trigger: LOW to HIGH transition initiates a new A/D conversion.
Flag Reset: LOW sets FLAG ($\overline{\text{FLAG}}$) to LOW (HIGH).
Control Logic Levels & Source Requirements: HIGH ≡ either an open circuit or a voltage between +2.4V and 5V referred to output LO. LOW ≡ closure to output LO within 0.8V while sinking +1.6 milliamperes (1TTL load). The $\overline{\text{HOLD}}$, $\overline{\text{TRIGGER MODE}}$, $\overline{\text{TRIGGER MODE DISABLE}}$, TRIGGER, and $\overline{\text{FLAG RESET}}$ lines control the Model 174 regardless of front panel setting. $\overline{\text{LOAD RANGE}}$ and Range Input Codes control range selection only in "V" and "Ω" functions, when the front panel "REM" (remote) pushbutton is depressed.

ISOLATION: All digital outputs and remote controls are isolated from 174 analog input by 10^9 Ω and 500pF, 1200 VDC, 1000V rms AC maximum. All digital outputs and remote controls are located from chassis ground by 10^6 Ω and 0.01µF; 250V rms maximum.

TABLE 4-3.
Summary of Remote Commands at P1101
(See also Figure 12)

Pin No.	Command	Pin No.	Command
1	CASE GND	14	$\overline{\text{RANGE STROBE}}$
2	COMMON	15	R4
3	COMMON	16	$\overline{\text{POLARITY STROBE}}$
4	$\overline{\text{AUTORANGED STROBE}}$	17	R8
5	$\overline{\text{TRIGGER MODE}}$	18	$\overline{10^4 \text{ STROBE}}$
6	$\overline{\text{AUTOMODE STROBE}}$	19	TRIGGER
7	$\overline{\text{HOLD}}$	20	$\overline{10^3 \text{ STROBE}}$
8	$\overline{\text{OVERFLOW STROBE}}$	21	$\overline{\text{FLAG RESET}}$
9	$\overline{\text{LOAD RANGE}}$	22	$\overline{10^2 \text{ STROBE}}$
10	$\overline{\text{FLAG/FLAG STROBE}}$	23	$\overline{\text{TRIGGER MODE DISABLE}}$
11	R1	24	$\overline{10^1 \text{ STROBE}}$
12	$\overline{\text{FUNCTION STROBE}}$	25	$\overline{\text{AUTORANGED}}$
13	R2	26	$\overline{10^0 \text{ STROBE}}$

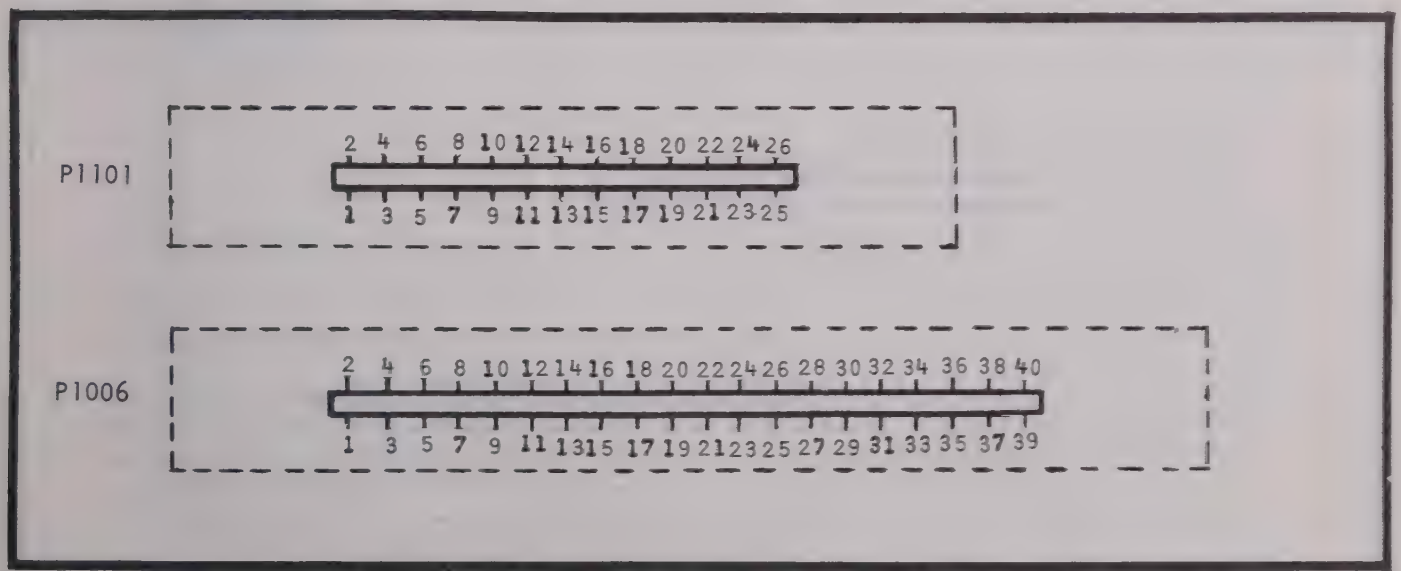


FIGURE 11a. Connector Pin Identification For Model 174/1722.

TABLE 4-4.
Summary of Digital Output at P1006
(See also Figure 12.)

Pin No.	Signal	Pin No.	Signal
1	CASE GND	21	10^4-2
2	COMMON	22	10^3-2
3	COMMON	23	10^4-1
4	COMMON	24	10^3-1
5	COMMON	25	10^2-8
6	$\overline{\text{PRINTER HOLD}}$	26	10^1-8
7	AUTOMODE	27	10^2-4
8	VEXT	28	10^1-4
9	R8	29	10^2-2
10	VOLTS	30	10^1-2
11	R4	31	10^2-1
12	AMPS	32	10^1-1
13	R2	33	10^0-8
14	AC	34	$\overline{\text{FLAG}}$
15	R1	35	10^0-4
16	OHMS	36	FLAG
17	10^4-8	37	10^0-2
18	10^3-8	38	OVERFLOW
19	10^4-4	39	10^0-1
20	10^3-4	40	POLARITY

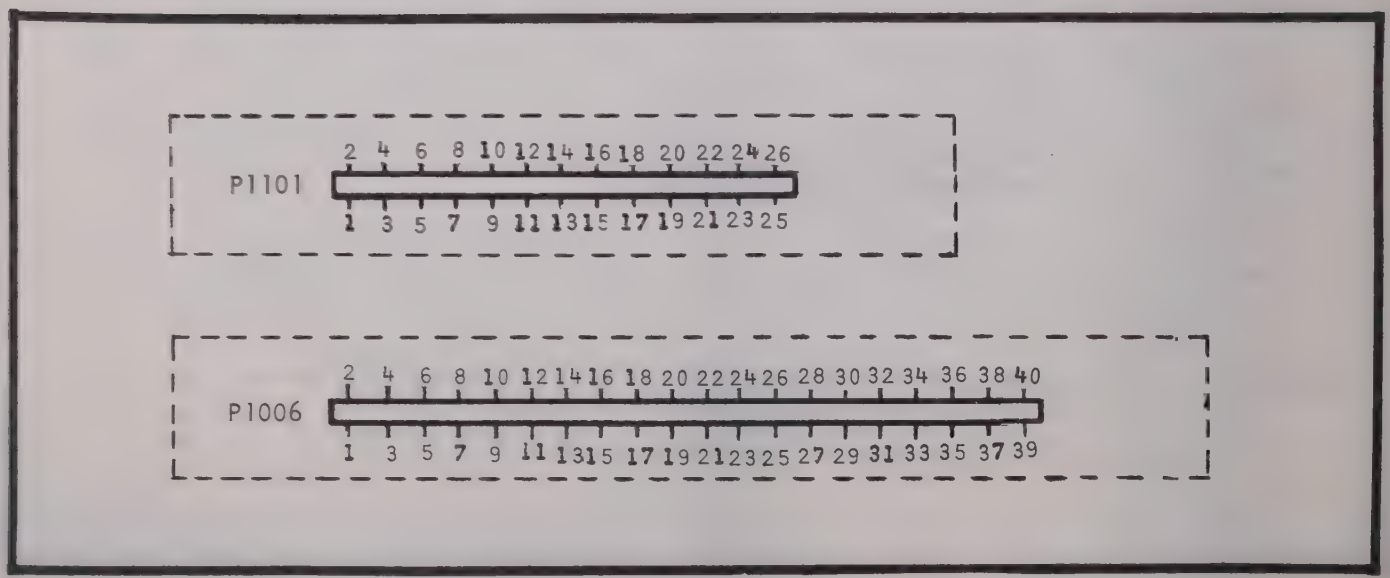


FIGURE 11b. Connector Pin Identification For Model 174/1722.

TABLE 4-5.
(Model 1722 Range & Function Coding For Model 174)

FUNCTION	OUTPUT FUNCTION CODE (1)	RANGE	OUTPUT RANGE CODE (1)	(EXP)	INPUT RANGE CODE (1) (2)	
	V A AC Ω		R_8 R_4 R_2 R_1		R_8 R_4 R_2 R_1	
DC VOLTS	1 0 0 0				1 1 1 1	AUTORANGE
		3 mV	0 0 1 1	3	1 1 0 0	
		30 mV	0 1 0 0	4	1 0 1 1	
		300 mV	0 1 0 1	5	1 0 1 0	
		3 V	0 1 1 0	6	1 0 0 1	
		30 V	0 1 1 1	7	1 0 0 0	
		300 V	1 0 0 0	8	0 1 1 1	
		1200 V	1 0 0 1	9	0 1 1 0	
AC VOLTS	1 0 1 0				1 1 1 1	AUTORANGE
		300 mV	0 1 0 1	5	1 0 1 0	
		3 V	0 1 1 0	6	1 0 0 1	
		30 V	0 1 1 1	7	1 0 0 0	
		300 V	1 0 0 0	8	0 1 1 1	
		1000 V	1 0 0 1	9	0 1 1 0	
LOW Ω	0 0 0 1				1 1 1 1	AUTORANGE
		300 Ω	0 0 1 0	2	1 1 0 1	
		3 kΩ	0 0 1 1	3	1 1 0 0	
		30 kΩ	0 1 0 0	4	1 0 1 1	
		300 kΩ	0 1 0 1	5	1 0 1 0	
		3 MΩ	0 1 1 0	6	1 0 0 1	
		30 MΩ	0 1 1 1	7	1 0 0 0	
HI Ω	0 0 1 0				1 1 1 1	AUTORANGE
		3 kΩ	0 0 1 1	3	1 1 0 0	
		30 kΩ	0 1 0 0	4	1 0 1 1	
		300 kΩ	0 1 0 1	5	1 0 1 0	
		3 MΩ	0 1 1 0	6	1 0 0 1	
		30 MΩ	0 1 1 1	7	1 0 0 0	
		300 MΩ	1 0 0 0	8	0 1 1 1	

(1) Coding in this table is defined to be HIGH (POSITIVE) TRUE. "1" = HIGH and "0" = LOW. Refer to output and remote control logic levels for definitions of HIGH & LOW.

(2) Note that except for AUTORANGE CODE, INPUT & RANGE CODE is the compliment of the OUTPUT RANGE CODE, i.e. the INPUT RANGE CODE is the LOW TRUE BCD code of (EXP).

(3) Note that (EXP) is directly the exponent of 10 if the numerical readings are defined as follows:

VOLTS: Unit = μV
OHMS: Unit = Ω
AMPS: Unit = nA

TABLE 4-5. (Con't)
(Model 1722 Range & Function Coding For Model 174)

FUNCTION	OUTPUT FUNCTION CODE (1)	RANGE	OUTPUT RANGE CODE (1)	(EXP)	INPUT RANGE CODE (1) (2)
	V A AC Ω		R_8 R_4 R_2 R_1		R_8 R_4 R_2 R_1
DC AMPS	0 1 0 0				NO AUTORANGE OR
		3 µA	0 0 1 1	3	REMOTELY PROGRAMMED
		30 µA	0 1 0 0	4	
		300 µA	0 1 0 1	5	CURRENT RANGES.
		3 mA	0 1 1 0	6	
		30 mA	0 1 1 1	7	
		300 mA	1 0 0 0	8	
		3 A	1 0 0 1	9	
AC AMPS	0 1 1 0	3 µA	0 0 1 1	3	
		30 µA	0 1 0 0	4	
		300 µA	0 1 0 1	5	
		3 mA	0 1 1 0	6	
		30 mA	0 1 1 1	7	
		300 mA	1 0 0 0	8	
		3 A	1 0 0 1	9	

d. How to Select Vext Using Internal Jumper. The Model 1722 may be wired for use with internal or external voltage references and internal pull-up resistors. (See Figure 16.)

1. Jumper A. When this jumper is installed, the pull-up resistors are connected to the external reference Vext (pin 8, P1006).

2. Jumper B. When this jumper is installed, the pull-up resistors are connected to the internal reference (+5V).

3. Jumper C. When this jumper is installed, Vext is connected to internal +5V reference. The pull-up resistors are not connected in this instance. The +5 volt reference is rated at 40 mA maximum.

TABLE 4-6.
Digital Output Lines Grouped By Function.

Name	P1006 Pin No.	P1101 Pin No.	Name	P1006 Pin No.	P1101 Pin No.
$\overline{10^0}$ STROBE	--	26	$\overline{\text{FUNCTION STROBE}}$		12
10^0-1	32		-VOLTS	10	
10^0-2	37		-AMPS	12	
10^0-4	35		-AC	14	
10^0-8	33		-OHMS	16	
$\overline{10^1}$ STROBE	--	24	$\overline{\text{OVERFLOW STROBE}}$		8
10^1-1	32		-OVERFLOW	38	
10^1-2	30		$\overline{\text{AUTOMODE STROBE}}$		6
10^1-4	28		-AUTOMODE	7	
10^1-8	26		$\overline{\text{AUTORANGED STROBE}}$		4
$\overline{10^2}$ STROBE	--	22	-AUTORANGED		25
10^2-1	31		$\overline{\text{PRINTER HOLD}}$	6	
10^2-2	29		$\overline{\text{TRIGGER MODE}}$		5
10^2-4	27		$\overline{\text{HOLD}}$		7
10^2-8	25		LOAD RANGE		9
$\overline{10^3}$ STROBE	--	20	R1		11
10^3-1	24		R2		13
10^3-2	22		R4		15
10^3-4	20		R8		17
10^3-8	18		$\overline{\text{TRIGGER}}$		19
$\overline{10^4}$ STROBE	--	18	$\overline{\text{FLAG RESET}}$		21
10^4-1	23		$\overline{\text{TRIGGER MODE DISABLE}}$		33
10^4-2	21		COMMON	2,3,4,5	2,3
10^4-4	19		CASE	1	1
10^4-8	17				
$\overline{\text{POLARITY STROBE}}$	--	16			
$\overline{\text{RANGE STROBE}}$	--	14	FLAG/$\overline{\text{FLAG}}$ STROBE	--	10
-R1	15		$\overline{\text{FLAG}}$	36	
-R2	13		FLAG	34	
-R4	11		VEXT	8	
-R8	9				

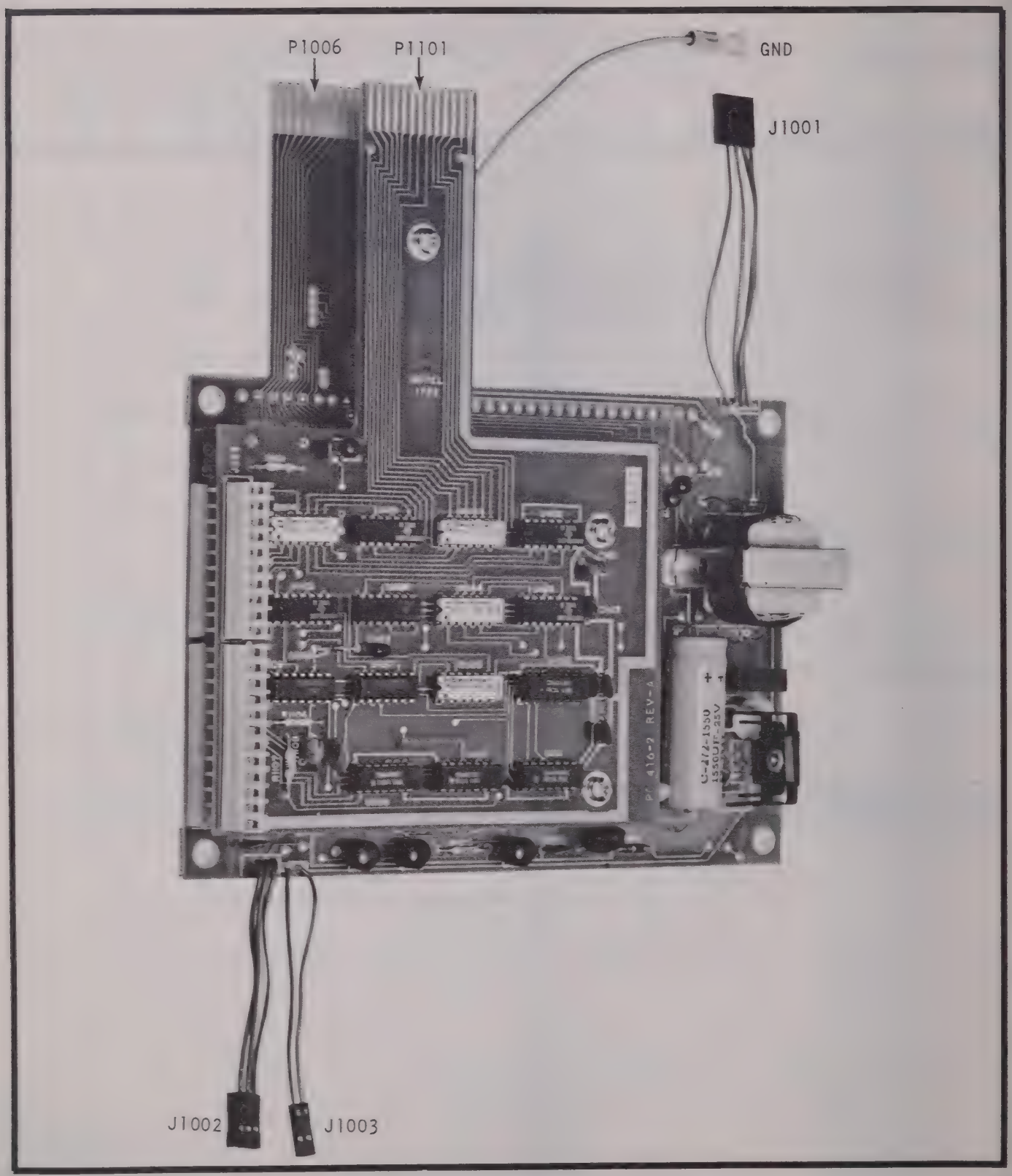


FIGURE 12. Model 1722 Digital Interface.

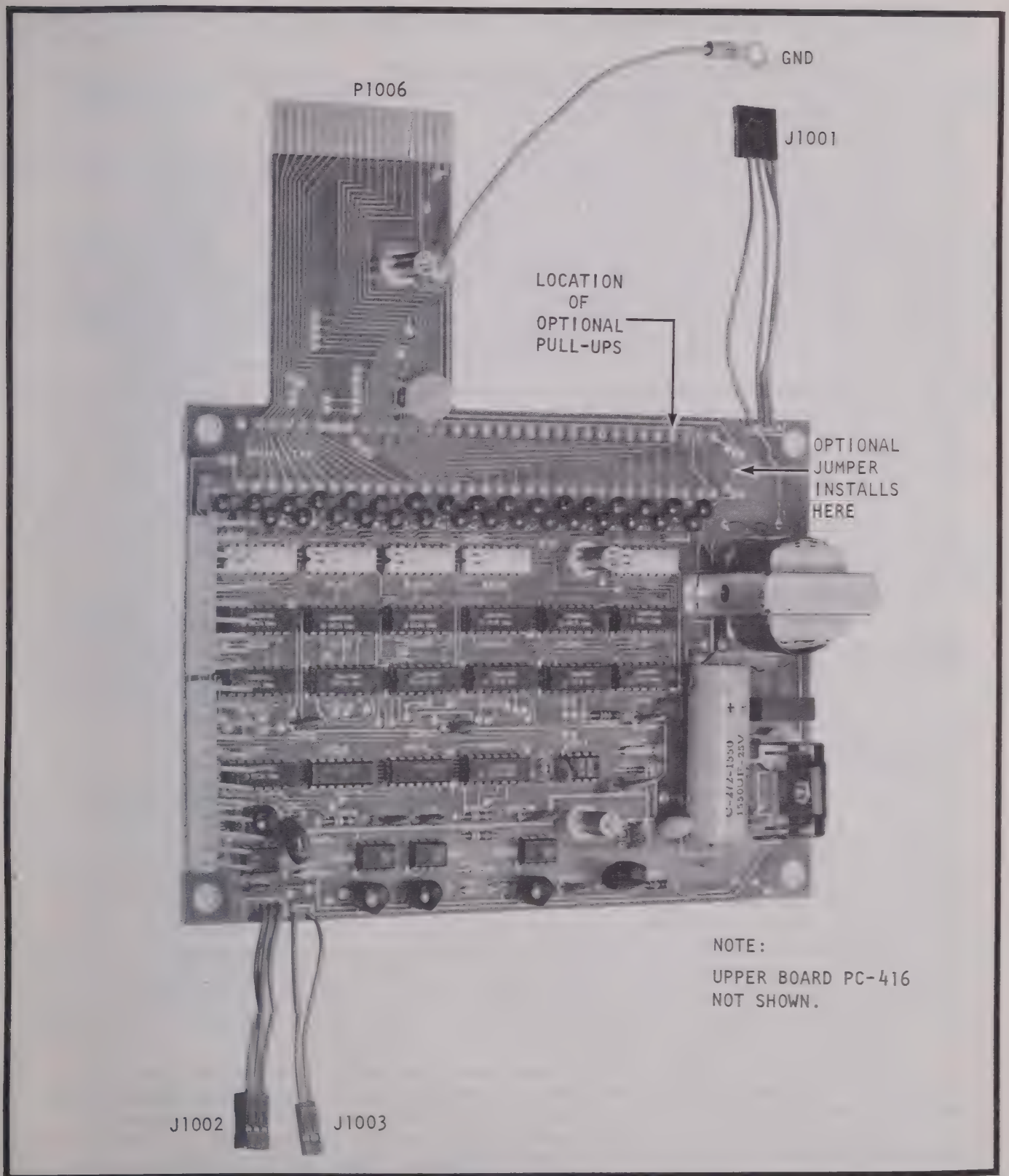


FIGURE 13. Location of Jumpers and Pull-Ups For Model 1722

e. Detailed Explanation of Model 1722. (Schematics and Timing Diagrams are at the end of the Manual.)

1. TRIGGER MODE AND TRIGGER (Timing Diagram 28248E): When TRIGGER MODE is active (Low), output data and display will not be updated. TRIGGER MODE enables TRIGGER. Conversion starts within 1.6 milliseconds after RISING TRIGGER. Integration starts 120 milliseconds after start of conversion.

2. HOLD: If either HOLD or PRINTER HOLD is low, the output data and the display will not be updated and the FLAG will stay at HIGH (unless reset by FLAG RESET).

3. LOAD RANGE: When LOAD RANGE is low the 174 will go to the range as set by the RANGE IN code (Table 4-5) at the beginning of the next conversion. As long as LOAD RANGE is held low the instrument will remain on its programmed range, provided the "REM" pushbutton on the front panel is depressed. RANGE IN codes programmed outside the limits of Table 4-5 will result in the nearest valid range to that programmed. LOAD RANGE will always set the DMM to the newly programmed range. However, the display and output data will be held until the end of the first complete conversion on the new range.

4. REMOTE CONTROLS: Referring to timing schematic 28249D it is possible to just miss a REMOTE CONTROL update prior to data output. This can be misleading especially in the case of HOLD. A HOLD just missed (unknown to the user) just before data begins to change could result in erroneous data. To check if this occurred, it is suggested that the FLAG be examined no sooner than 10 µsec after activation of the HOLD bit. If flag is low wait until it goes to HIGH before expecting the HOLD bit to have been accepted. Other REMOTE CONTROL bits such as TRIGGER MODE and TRIGGER, LOAD RANGE and the RANGE IN code can be kept active for longer than an output data update time, i.e. >3.2 msec to insure proper REMOTE CONTROL acceptance.

5. TRIGGER MODE DISABLE: When in TRIGGER MODE and triggering the autorange mode, normal operation will give an output for each range encountered during the autorange. However, if this is undesirable the AUTORANGED output bit can be tied to TRIGGER MODE DISABLE and FLAG RESET. This will prevent the FLAG from being set and ignore further triggering until the final range is reached. The FLAG will indicate a valid reading after the second conversion on the final range. Then operation will revert to normal trigger mode operation.

f. Circuit Description.

1. Overall Block Diagram. As shown in Figure 14 Serial data from the DMM and its associated clock lines are first isolated. Bidirectional data line SERDAT is then split. Output data DOWNDAT goes to the output register block where it is converted to parallel form and then to the output buffers. The clock lines go to the control block which decides where the data is going, out or in, and also generates the flag. Control input data and strobes are first buffered by the input buffer block. The strobes go to the output buffer to gate the outputs. The control data inputs go to the input register and control block where they are converted from parallel to serial form and sent to the isolation block. The input register and control block also decides, based on control data input, whether there is to be an output update. Power isolation for the 1722 is provided by transformer T1001 which is powered by a secondary winding of the DMM power transformer.

2. Signal Isolation. The bidirectional data line SERDAT and the two clock lines SERCLK and INCLK each drive an emitter follower made up of transistors Q1036, Q1035, and Q1037 whose loads are LED's in the opto-isolators are pulled up by resistors R1010, R1009 and U1018, which is driven by Q1034 similar to the three just mentioned. The output pullup on U1018 is on the DMM mainframe. Power for the DMM side of the isolation is taken directly from the DMM +5 volts through R1016 and C1018 and C1017, which provide the coupling.

3. Power Supply. Low voltage ac from the secondary of the DMM transformer is supplied via pins B and C on J101A.

Switching for the power for T1001 provided at J1003 Pins A and B and comes via the DMM mainframe through its Power On switch. The secondary of T1001 is rectified, filtered and run through an integrated circuit +5V regulator TR1001, where it is again filtered by C1015, C1002, C1003, C1004, C1014. The core of T1001 is connected to chassis ground by a green wire to a screw on the DMM mainframe or transformer. Also common mode filtering is performed by R1008 and C1006 between output low and chassis ground.

4. Control Block. UPCLK, the isolated form of INCLK, is run to the trigger input of E1017 timer. A buffered version of UPCLK is also run via diode gate CR1002 to the threshhold input of U1017. U1017 is such that its output will go high when a falling edge goes into trigger. A filter made up of R1007 and C1008 will try to charge, however, since this threshhold is clamped low through diode CR1002. It will not be able to time out in the time period of the clock pulses on INCLK until the last rising edge of INCLK, at which time it will clock out at 30 microseconds, therefore UPTIME, the output of U1017, will be length of the INCLK pulse stream plus approximately 30 microseconds, which is the time in which data will be flowing from the 174 to the DMM. This is done by clocking DOWNCLK with UPTIME in flip-flop U1015A. The beginning of downtime also defines the time when the flag is set high, that is when data has finished being updated. Setting the flag low during data change time, or resetting the flag, is accomplished in two ways: FR or UPDATE. Downtime also gates DOWNCLK thru U1014C & U1014D where it is called GATECLK and goes to the output register.

5. Output Register. The output register is made up of shift registers U1008A & B 1009A & B, 101A & B, 1011A & B. It is a 32-bit shift register, of which only 30 bits are used. Serial data enters U1008B and is clocked through all of the shift registers by the parallel clock, GATECLK. At the end of the clocking time all 30 bits have been shifted in and are presented in parallel to the output buffer.

6. Output Drive and Buffer. Parallel data on the output registers goes to output gates U1001 thru 1007 and U1012 and 1013. Here they are gated with the output strobes and drive transistors Q1001 through 1030 to output connector R1006.

7. Input Buffers. Strobe lines are buffered by U1101 and U1102 and go out to the output drive and buffer block. Remote control inputs are buffered by U1104, U1111, U1105. U1104 is a Schmitt trigger and is put on certain control lines to prevent false triggering.

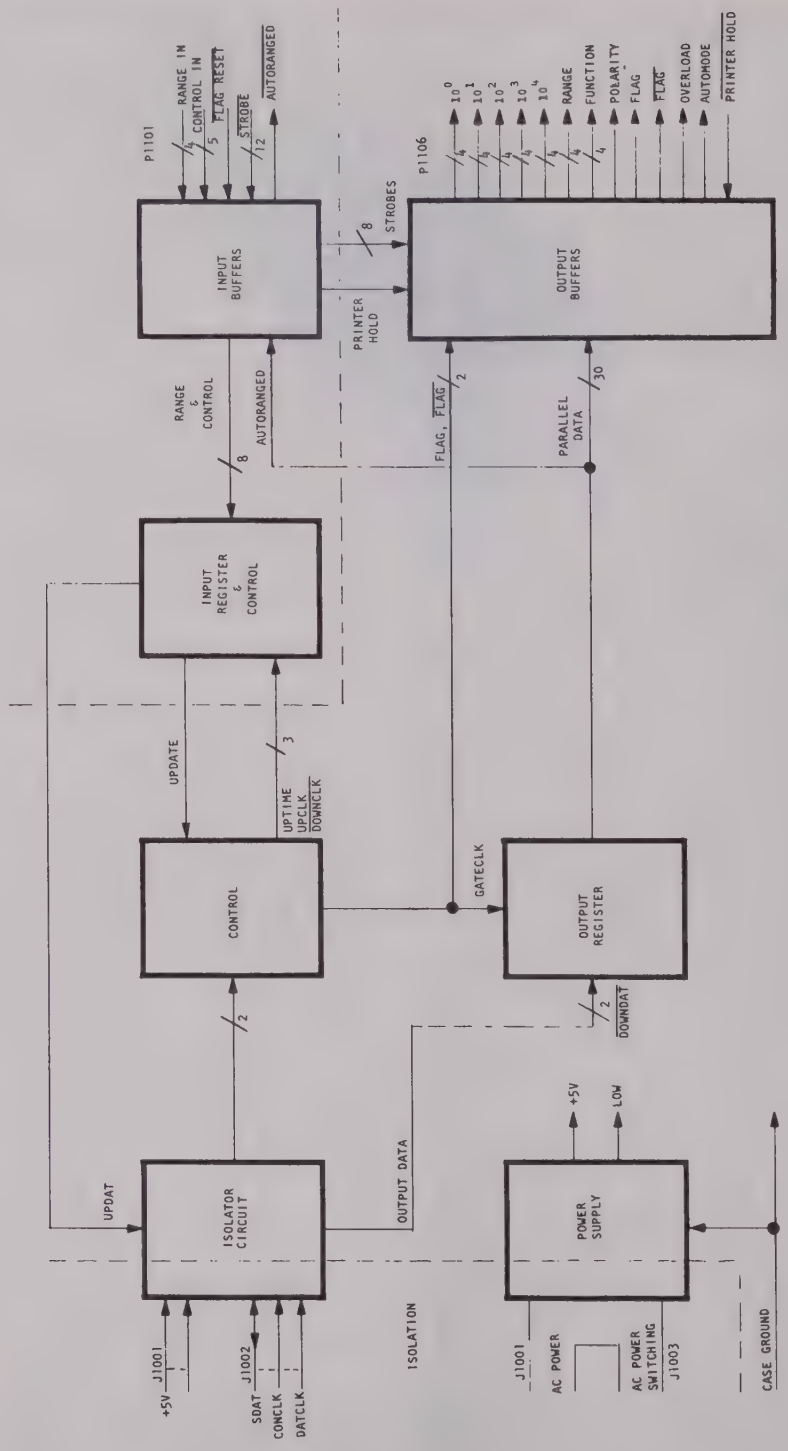


FIGURE 14. Model 1722 Block Diagram

4-4. RACK MOUNTING. The Model 174 can be rack mounted in a full rack (19 inch width) in either single or dual mounting configuration.

MODEL 2000 SINGLE RACK MOUNTING KIT

Description:

The Model 2000 is a rack mounting kit which converts any half-rack style "M" instrument from bench mounting to rack mounting in a standard 19-inch rack. The dimensions are 3-1/2 in. high x 19 in. wide. The hardware included in this kit consists of a blank panel and angle bracket which can be mounted on either side of a half-rack instrument.

TABLE 4-7.
Parts List For Model 2000.

Item No.	Description	Qty Req'd	Keithley Part No.	Illustration
21	Angle Bracket	1	26738B	
22	Screws, #6-32 x 5/8, Phillips	2	--	
27	Blank Panel	1	24781B	
28	Screws, #6-32 x 1/2, Phillips	2	--	
29	Screws, #10-32 x 3/8, Socket Hd.	2	--	
30	Angle Bracket (Staked)	1	26741B	
31	Kep Nut, #6-32	2	--	

Assembly Instructions: (Refer to Figure 15)

1. Before assembling the rack kit, determine the position of the instrument in the rack frame (either left or right position).

2. Once the position of the instrument has been determined, the "side dress" panels (Item 11) on each side of the instrument should be removed. Remove four screws (Item 24) to allow the side dress panels to slide toward the rear. The screws are replaced with longer screws (Item 22) furnished with the kit.

3. The bottom cover feet and tilt bail assemblies may be removed if desired. Original hardware, side dress panels, feet and tilt bail assemblies should be retained for future conversion back to bench mounting.

4. Attach "angle bracket" (Item 21) to left and right side of instrument using two #6-32 x 5/8 inch Phillips screws (Item 22). For 14 inch instrument use one #6-32 x 1/2 inch Phillips screw (Item 28) furnished with the kit. For 11 inch long instruments use two #6-32 x 5/8 inch Phillips screws and two Kep nuts.

5. Attach "blank panel" (Item 27) using two #10-32 x 3/8 inch Socket Hd screws (Item 29) furnished with the kit.

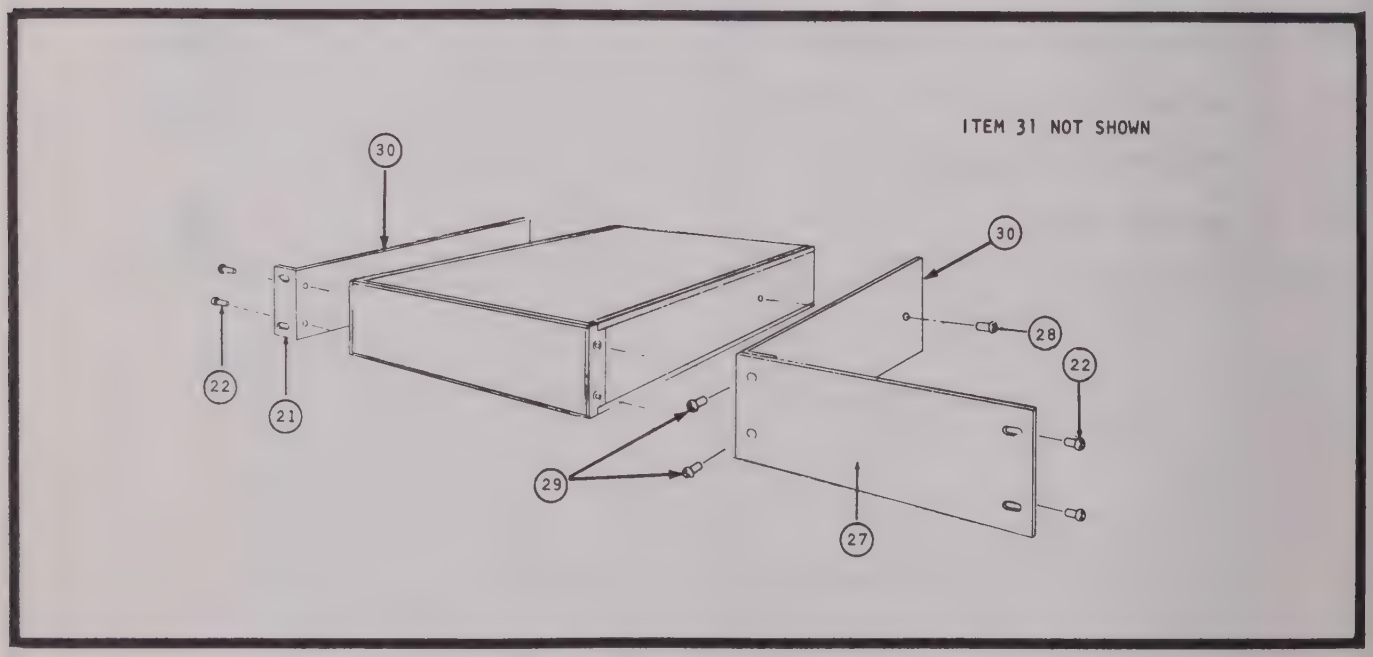


FIGURE 15. Model 2000 Rack Mounting Kit.

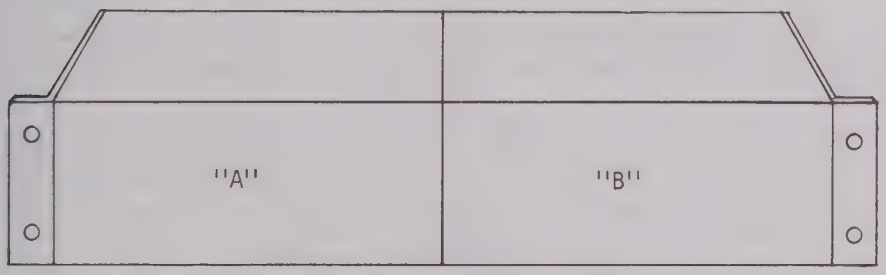
MODEL 1007 DUAL RACK MOUNTING KIT

Description:

The Model 1007 is a dual rack mounting kit with overall dimensions 3-1/2 in. (64 mm) high and 19 in. (483 mm) wide. The hardware included in this kit consists of two Angle Brackets, one Mounting Clamp, and extra mounting screws.

Application:

The Model 1007 converts any half-rack, style "M" instrument from bench mounting to rack mounting in a standard 19-inch rack. The kit may also be used for rack mounting 19-inch full rack width instruments.



The Model 1007 Rack Mounting Kit can be used to mount instruments of 11 inch or 14 inch depth. The user should decide the position of the instruments to be rack mounted. The Assembly Instructions refer to instruments positioned as above and identified as instrument "A" and "B".

TABLE 4-8.
Parts List For Model 1007.

Item No.	Description	Qty Req'd	Keithley Part No.	Illustration
22	Angle Bracket	2	27410B	
23	Screw, #6-32 x 5/8, Phillips Pan Hd	6	--	
24	Mounting Clamp	1	24798B	
25	Screw, #6-32 x 1, Phillips Pan Hd	1	--	
26	Kep Nut #6-32	3	--	
27	Screw, #6-32 x 1/2, Phillips Pan Hd	2	--	
28	Screw, #6-32 x 7/8, Phillips Pan Hd	1	--	

Assembly Instructions: (Refer to Figure 16)

1. Before assembling the rack kit, determine the position of each instrument. Since the instruments can be mounted in either location, their position should be determined by the user's measurement. The following instructions refer to instruments "A" and "B" positioned as shown. For mounting 19-inch full rack width instruments, disregard steps 2 through 5.

2. Once the position of each instrument has been determined, the "side dress" panels on both sides of each instrument should be removed. Removal is accomplished by loosening the screws (Item 8, original hardware) in two places. Slide the "side dress" panels to the rear of the instrument to remove.

3. The mounting clamp is installed on instrument "A" using the original hardware (Item 8). With the screws removed, insert the "mounting clamp" behind the "corner bracket" (Item 7) and replace the screws to hold the mounting clamp in place.

4. Tighten the screws (Item 8) on instrument "B". Insert the "mounting clamp" behind the "corner bracket" (Item 7) on instrument "B" as shown.

5. When mounting instruments having the same depth, a screw (Item 25) and kep nut (Item 26) are required to secure the two instrument together. When mounting instruments of different depth, do not use kep nut (Item 26) but substitute shorter screw (Item 28).

6. Attach an "angle bracket" (Item 22) on each instrument using hardware (Item 23) in place of the original hardware (Item 8). For 14 in. long instruments fasten angle brackets using #6-32 x 1/2 Phillips screws (Item 27). For 11 in. long instruments use #6-32 x 5/8 Phillips screw (Item 23) with #6-32 kep nut (Item 26).

7. The bottom cover feet and tilt bail assemblies may be removed if necessary.

8. The original hardware, side dress panels, feet and tilt bail assemblies should be retained for future conversion back to bench mounting.

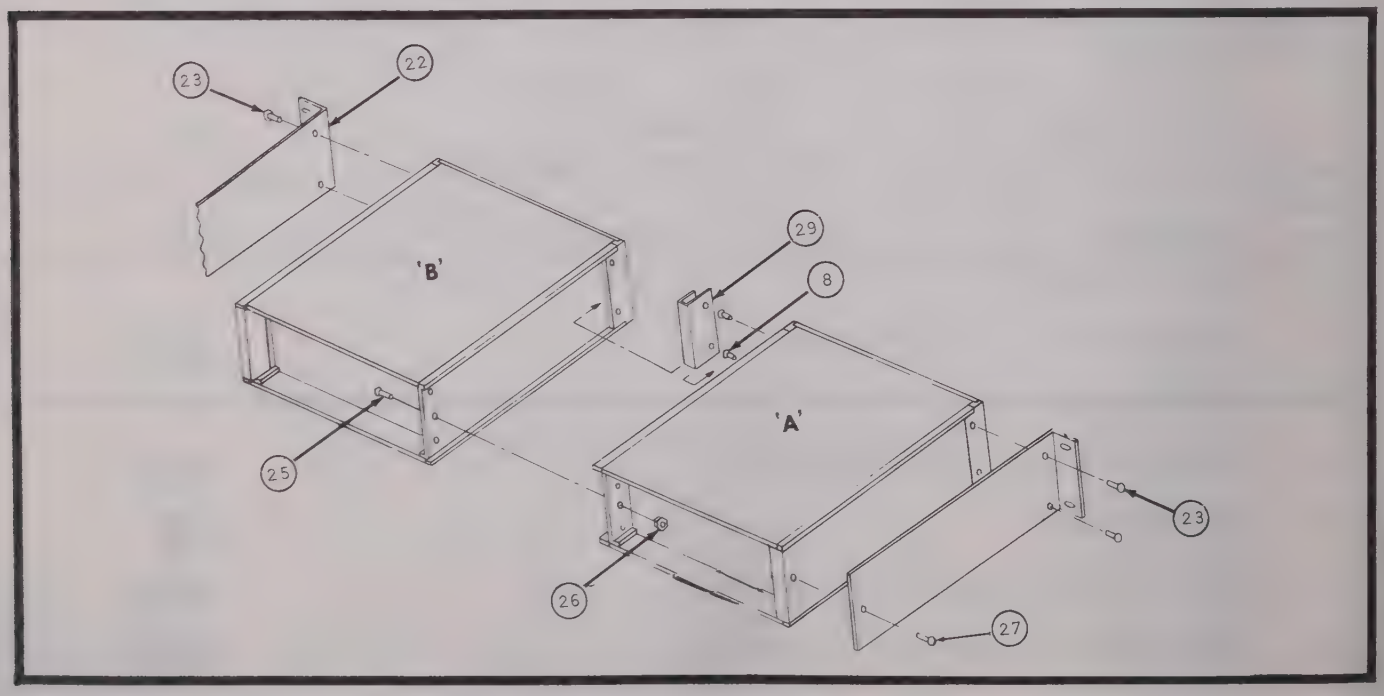


FIGURE 16. Model 1007 Dual Rack Mounting Kit.

4-5. PROBES AND SHUNTS. The following probes and shunts extend the capabilities of the Model 174. They are intended for use on various voltage or current ranges.

MODEL 1600 HIGH VOLTAGE PROBE

The Model 1600 is a divider probe for measurement of high voltage up to 40 kilovolts dc. The probe is optimized for use with a dc voltmeter having a 10 megohms input resistance. Thus, the Model 1600 should be used on 30V or high dc voltage ranges.

SPECIFICATIONS:
Voltage Range: 0 to 40,000 volts dc.*
Input Resistance: 1000 megohms.
Division Ratio: 1000:1
Ratio Accuracy (with 10MΩ Load): ±1.5% at 25kV, decreasing to
±2.0% at 20kV and 30kV
±3.0% at 10kV and 40kV, and
±4.0% at 1kV.
Ratio Stability: ±0.01% per °C; ±0.1% per year.
Heating Effects: Self-heating due to application of high voltage for periods in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltages).
*AC response at 1kV is flat within ±10% from 20Hz to 120 Hz. Division ratio is dependent on input impedance of multimeter used.

MODEL 1651 CURRENT SHUNT

The Model 1651 is a 0.001 ohm shunt (±1%) for use with an AC or DC voltmeter having at least 100 microvolts resolution. The shunt is rated at up to 50 amperes. The shunt can be used on the 300mV dc range on the Model 174, however, heating effects may cause some zero instability.

MODEL 1682 RF PROBE

The Model 1682 is an RF probe for measurement up to 100MHz. The Model 1682 is optimized for use with a DC voltmeter having 10 megohms input resistance. If the Model 1682 is used on the 300mV or 3V ranges, shunt the input terminals with a 10MΩ metal-film resistor to reduce the effective input resistance.

SPECIFICATIONS:
Voltage Range: 0.25 to 30 volts rms.
Transfer Accuracy: ±5%, 100kHz to 100MHz (20°-30°C); usable 1kHz to 1GHz; peak responding, calibrated in rms of a sine wave.
Input Impedance: 4MΩ shunted by 2 pF.
Maximum Allowable Input: 30V rms ac, 200V dc.
Accessories Supplied: Straight tip, hook tip, ground clip, rf adapter, banana plug adapter.

MODEL 1685 CLAMP-ON AC CURRENT PROBE

The Model 1685 is a clamp-on current probe for measurement of ac current up to 200 amperes. The Model 1685 is used with an AC Voltmeter and provides an output of 0.1 volt rms per ampere.

SPECIFICATIONS:
Range: 2, 20 and 200 amperes rms.
Accuracy: ±4% of range at 60 Hz.
±6% of range at 50 Hz.
Temperature Coefficient: ±0.05%/°C on the 20 and 200 ampere ranges. ±0.3%/°C on the 2 ampere range.
Maximum Allowable Current: 300 amperes rms.
Maximum Conductor Voltage: 600 volts rms.
Conversion Ratio: 0.1 volt rms per ampere.

4-6. CONVENIENCE CABLES AND CONNECTORS. The following cables and connection kits enable effective use of the Model 174 on the 300mV and higher ranges.

MODEL 1681 CLIP-ON TEST LEAD KIT

The Model 1681 is a set of test leads, 48 in. (1,2m) in length, terminated by a banana plug and spring-action clip-on probe.

MODEL 1683 UNIVERSAL TEST LEAD KIT

The Model 1683 is a set of flexible test leads, 40 in. (1m) in length, with interchangeable screw-on adapters.

4-7. LOW-THERMAL CABLES.

MODEL 1746A LOW THERMAL SHORT

The Model 1746A is supplied with each Model 174. The "bunch pin" type connectors make a sliding contact along the inside of the input terminal. This minimizes variations in thermal emfs and resistance. The low thermal short is used to verify proper operation on the 3mV DC and 300Ω LO ranges.

MODEL 1747A LOW THERMAL INPUT CABLE

The Model 1747A is a low-thermal input cable with "bunch pin" type connectors to mate with the Model 174 input, and copper alligator clips for convenient connection to the circuit under test. The cable is 3 feet long and is tested to 10^{11} Ω insulation resistance during manufacture.

Since many other types of banana plugs may create thermal emfs which vary in excess of the Model 174 input variations, the Model 1747A is recommended for low voltage dc measurements on 3mV DC and 30mV DC ranges. The cable is also useful as a shielded high impedance cable for AC or high resistance measurements.

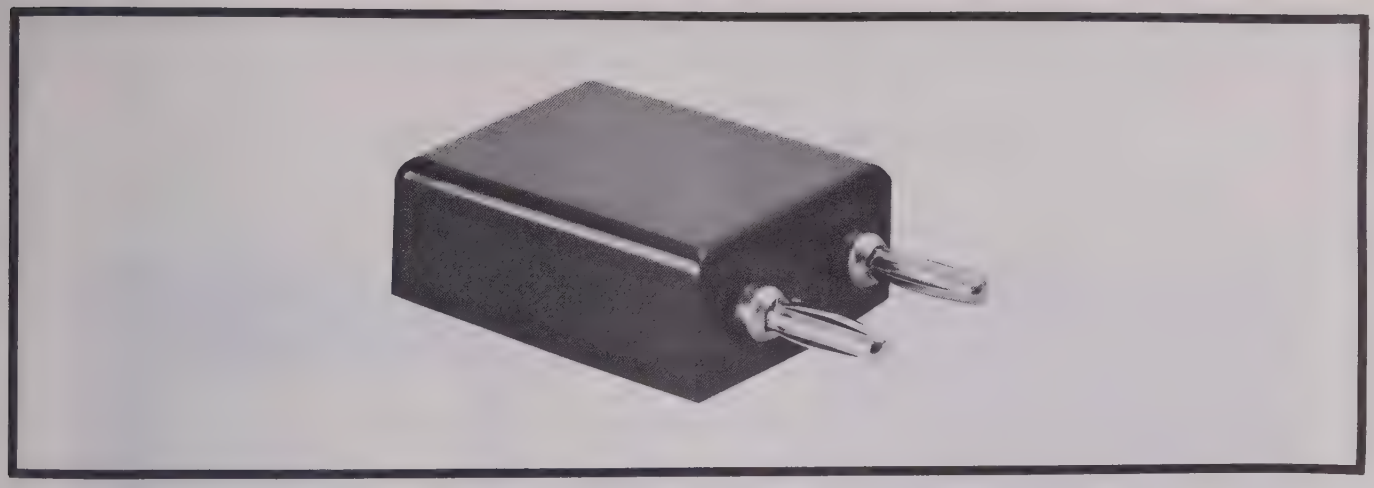


FIGURE 17. Model 1746A Low-Thermal Shorting Plug

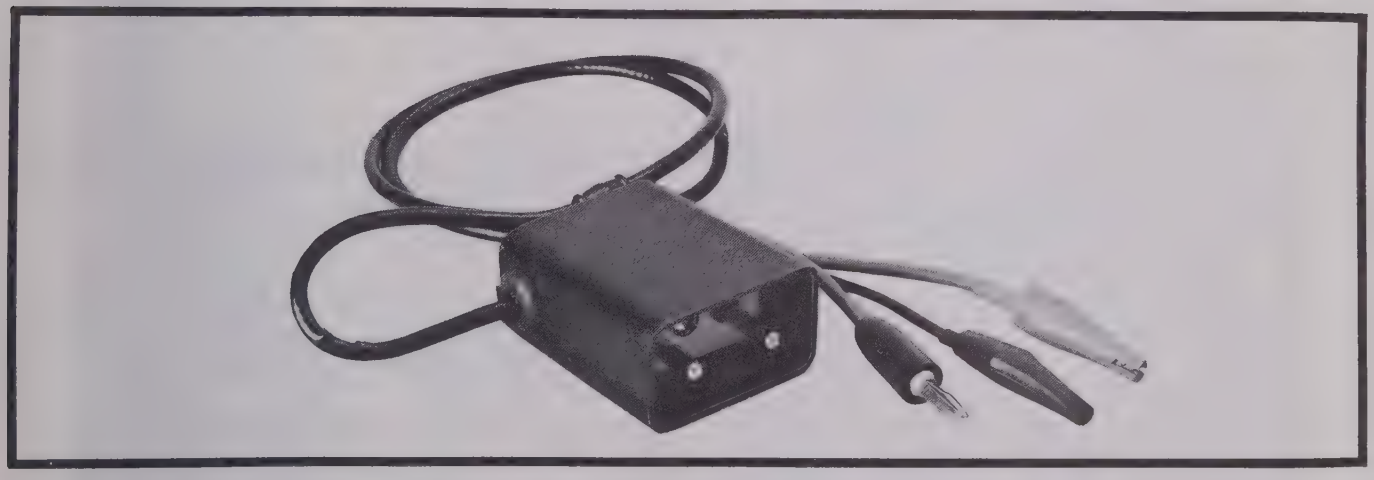


FIGURE 18. Model 1747A Low-Thermal Cable Set

4-8. MODEL 1727 DIGITAL OUTPUT CABLE SET. The Model 1727 is a cable set consisting of 26- and 40- conductor ribbon cable terminated by mating card-edge connectors to the Model 1722. The Model 1727-03 is 3 feet long (1 m), and the Model 1727-10 is ten feet long (3,1 m). The pins on the connectors are identified in Figure 11. (page 4-9).

4-9. MODEL 1723 IEEE INTERFACE. The Model 1723 is a microprocessor-based IEEE Standard 488-1975 Bus Interface that provides the logic and control functions necessary to interface the Keithley Model 174. The Model 1723 has a single interface board that mounts within the Model 174. Installation and operating instructions are furnished in the Model 1723 Instruction Manual.

4-10. MODEL 1743 MAINTENANCE KIT. This kit contains the following items which are necessary for adjustment/calibration and troubleshooting of the Model 174.

TABLE 4-10.
Summary of Items Furnished With the Model 1743.

Item	Description	Keithley Part No.
1	Extender cable set for Digital Board, PC-421.	28706C
1a	9 brown, 1 gray conductors. Connects between J702 on PC-421 and P902 on PC-412.	
1b	9 yellow, 1 brown conductors. Connects between J703 on PC-421 and P903 on PC-412.	
1c	9 gray, 1 blue conductors. Connects between J704 on PC-421 and P904 on PC-412.	
1d	9 blue, 1 yellow conductors. Connects between J705 on PC-421 and P905 on PC-412.	
2	Extender card for Model 1744 Ohms Board (PC-408). This extender card is labeled as PC-439 and enables the ohms board to be extended for access to circuit test points, etc.	28696B
3	Extender card for Model 1745 Current Board (PC-409). This extender card is labeled as PC-440 and enables the Current Board to be extended for access to circuit test points, etc.	28699B
4	Extender card for Model 1740 AC Board (PC-414). This extender card is labeled as PC-441 and enables the AC Board to be extended for access to circuit test points, etc.	28702C
5	Extender card for upper board (PC-416) of Model 1722 Digital Interface. This extender card is labeled as PC-437 and enables the upper board to be extended for access to the lower board (PC-415). See the illustration of the extender card assembly in Figure 20.	28610B
6	PC Card Extractor. Enables the removal of pc boards for servicing.	21257A
7	Cable Assembly. 2 brown, 1 white conductors. Connects between J1002 on Model 1722 and P701 on PC-421.	28709B
8	Cable Assembly, 1 brown, 1 white conductors. Connects between J1003 on Model 1722 and P403 on PC-412.	28710B
9	Cable Assembly, 3 brown, 1 white conductors. Connects between J1001 on Model 1722 and P404 on PC-412.	28711B
10	Test Lead Assembly, 1 red, 1 black conductors. Connects between TP101 and TP102 on PC-412 and Oscilloscope. See Section 6, MAINTENANCE.	28623A
11	Test Lead Assembly, 1 green conductor. Connects between TP702 an PC-421 and Oscilloscope LOW as described in Section 6, MAINTENANCE.	28622A
12	Test Lead Assembly. 1 violet conductor. Used only when the Model 1740 AC Option is installed. Extends the violet wire connection from function switch to Model 1740.	28707A
13	Calibration Cover (requires thumb screws).	28712D
14	Thumb Screws (4 pieces). Used to fasten the Calibration Cover.	
15	Instruction Manual, Model 174 (Contains Performance Verification and Adjustment/Calibration information in Section 6, MAINTENANCE.	28263

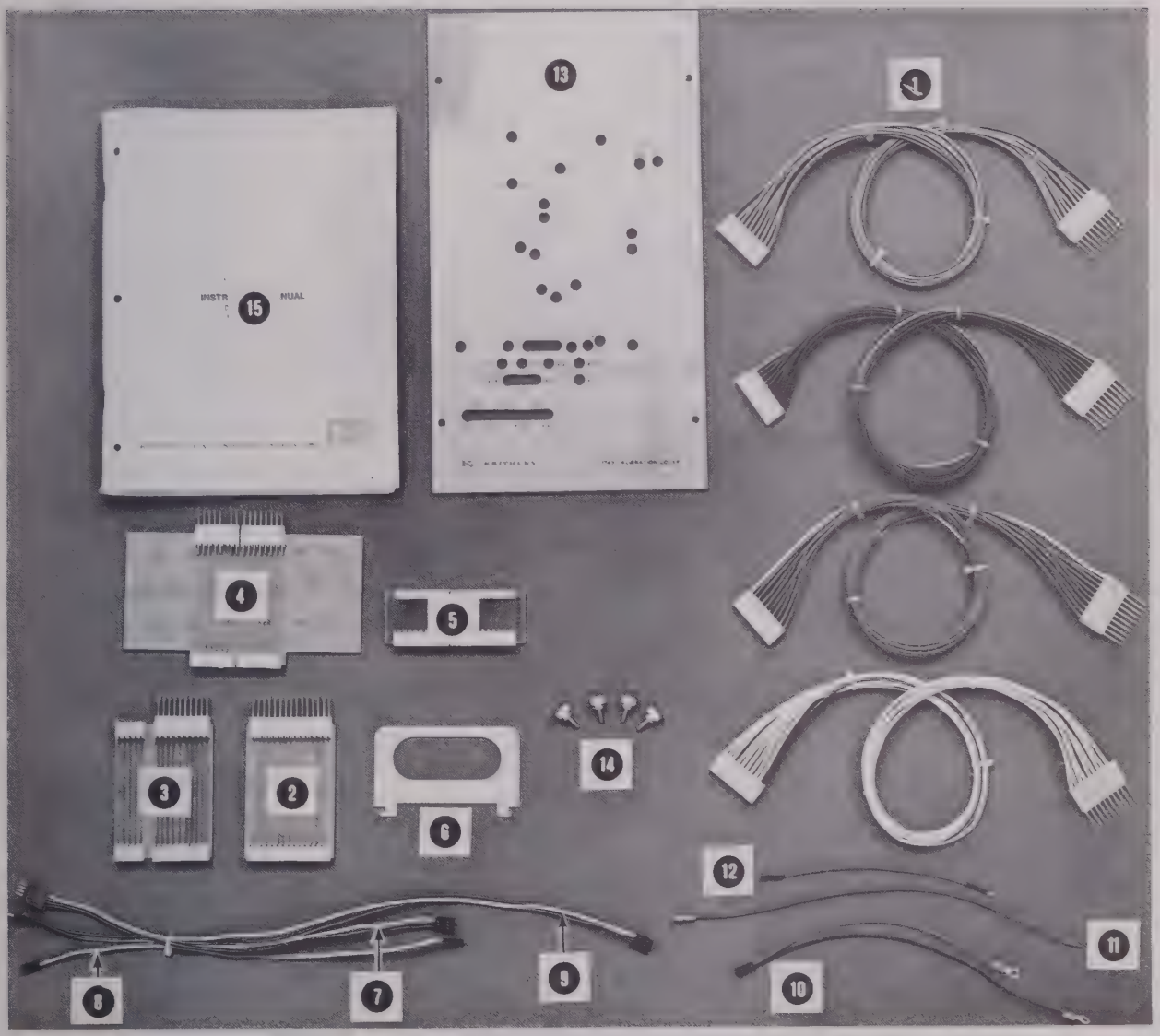


FIGURE 19. Model 1743 Maintenance Kit

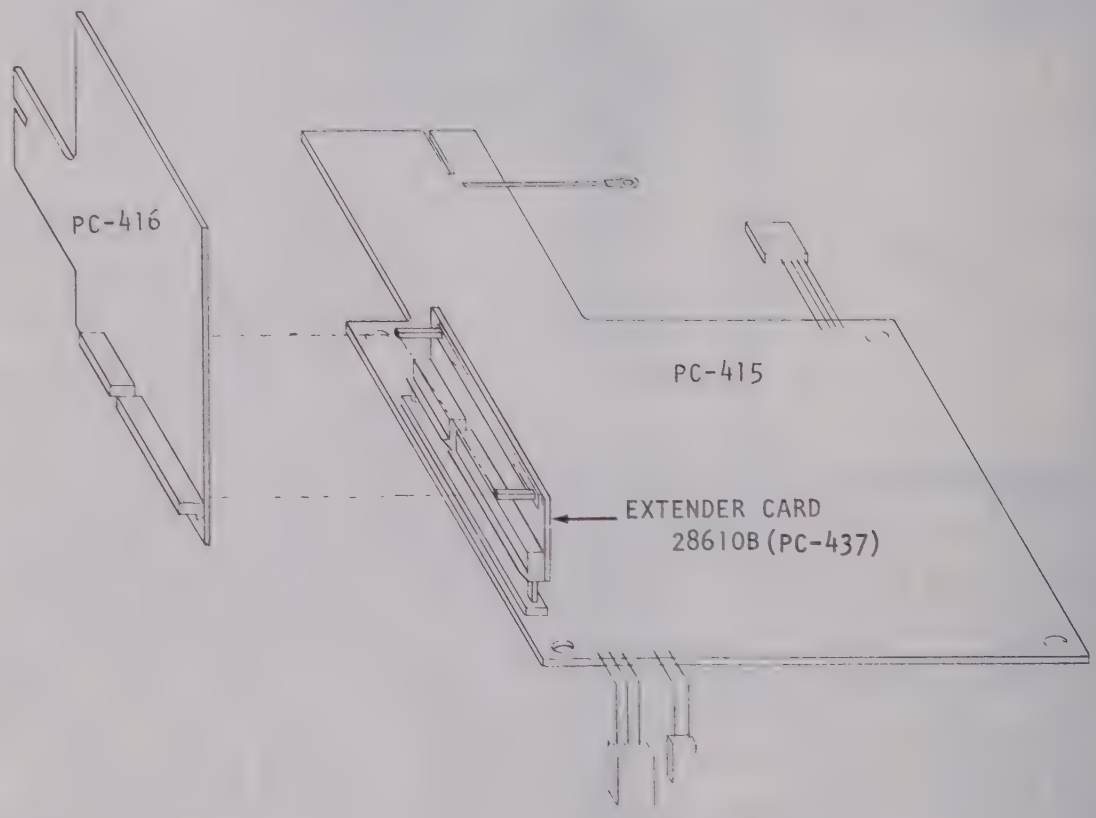


FIGURE 20. Typical Installation of Extender Card on Model 1722.

SECTION 5. THEORY OF OPERATION.

5-1. GENERAL. This section contains circuit descriptions for the Model 174 mainframe and options.

5-2. SIGNAL FLOW. The overall flow diagram is shown in Figure 21.

a. The "input switching" network consists of switch S302 (deck 4 front and deck 1 front), relay K503, and the rear 2 sections of range pushbuttons (S301). All these components and switching details are shown on the Switching schematic 27935E.

b. The "input switching" connects the signal to one of the various signal conditioning circuits shown in Figure 21, then to the output switching consisting of S302 (deck 1, rear), and relays K501 and K502. The signal then goes through an active ac filter (U901, Zone M-3) to the A/D input (A/D SIG).

c. The A/D makes 2 sequential measurements during each conversion. The first is between "AZ1" and "A/D CAL" to autocalibrate the A/D converter. The second is between "AZ2" and "A/D SIG" which autozeros the A/D and integrates the signal for 200ms. Switch S302 (Deck 3) accomplishes the necessary switching for AZ1, AZ2, and A/D CAL. The A/D converter is shown on schematic 27936F which includes the LSI device (U103). The A/D converter and switching are located on the Mother board (PC-412).

d. The output of U103 goes to the display board (PC-410, schematic 27939D) in the form of segment and timing lines a through g, dp, MI, and NMC. A serial output (SERDAT) and a clock line (SERCLK), which provides appropriate timing signals for a shift register, connect to the Model 1722 or 1723 digital interface through the digital board (PC-421, schematic 28209E, Zone H-1, I-1).

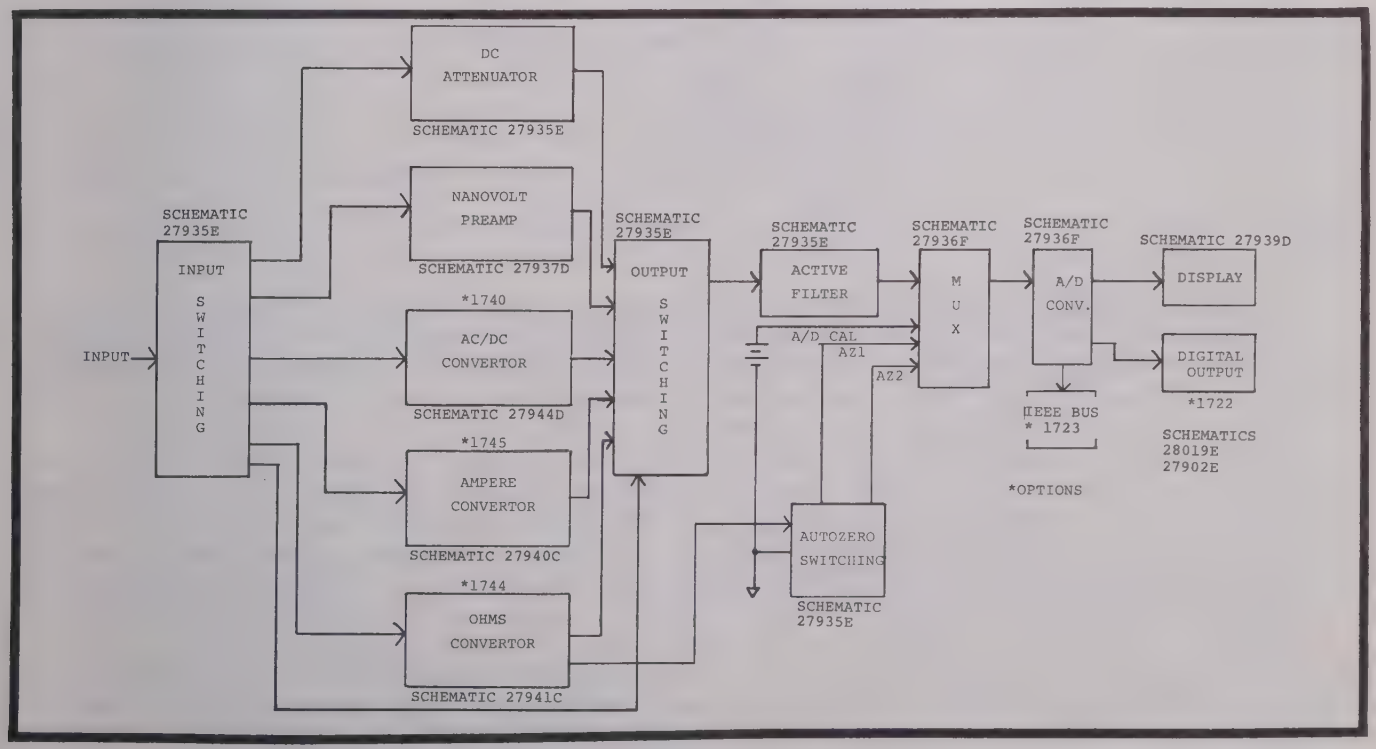


FIGURE 21. Diagram of Signal Flow.

e. In addition to these signal flow schematics, the power supply (located on PC-412) is shown on schematic 27938D. The optional battery pack, Model 1728 is shown on schematic 26758C.

NOTE

Each separate model number (e.g. 174, 1728) has an independent set of schematic designations. Mating connector numbers are noted on the various Model 174 schematics.

5-3. SWITCHING (Schematic 27935E).

a. Function Switch S302. The front panel rotary function switch has four decks and provides six positions: ACV, DCV, HIΩ, LOΩ, DCA, ACA. The purpose of each deck is summarized in Table 5-1.

TABLE 5-1.
Summary of Function Switching

DECK NO.	FRONT/REAR	ACTION OF SWITCH
1	Front	Switches INPUT LO.
1	Rear	Selects signal conditioning output for A/D converter.
2	Front	Encodes the 3-bit function code to integrated circuit U103 on VI, AC DC and Ω lines.
2	Rear	Selects inputs for "NBI" indication. section 5-9e.
3	Front	Selects A/D CAL and AZ_1 input.
3	Rear	Selects AZ_2 input.
4	Front	Switches INPUT HI.
4	Rear	Connects AC input to on DC. Loads the Model 1745 output with 2MΩ.

b. Range Switch S301.

1. Manual Range Pushbuttons (300Ω through 1000V, 3A): Pins 1-2-3 and 7-8-9 on all pushbuttons, pins 4-5-6 of 300 (V-MΩ-mA) pushbutton, and pins 10-11-12 of 30 (V-MΩ-mA) pushbutton encode 4-bit, low-true, 1248 BCD range code on NR1S, NR2S, NR4S, and NR8S. Pins 4-5-6 and 10-11-12 of 3A pushbutton, pins 10-11-12 of 300mA pushbutton, and pins 10-11-12 of 30μA pushbutton connect AMPS input (S302, deck 4, front, pin 8) to the specific current range input on P504 or P505. Notice that if none of the pushbuttons in this set are depressed, AMPS input is connected to the 3μA input. Pin 4-5-6 of the 30μA pushbutton and 10-11-12 of the 3μA pushbutton connect the "current protect" line to amps input if neither of these ranges is selected. Thus the current sensing resistors are diode protected on the 300μA through 3A ranges. Pins 4-5-6 of the 3μA pushbutton connect the A/D input (via S302, deck 1, rear, pin 5) to the "3μA input" when that range is selected, or to the "30μA input" (via 30μA pushbutton pins 11-12) when 30μA or higher range is selected. When no range is selected or 300Ω, AUTO, or REM is depressed, the A/D input is open, and the display reads near zero. All range pushbuttons are mechanically interlocked so that only one may be depressed at a given time.

2. "AUTO" Pushbutton. Electrically this switch does nothing. Mechanically it is interlocked with the other range pushbuttons, so that when it is depressed, the AUTO range code is selected (NR1S = NR2S = NR4S = NR8S = +5V).

3. "REM" Pushbutton. When this pushbutton is depressed "NREM" is active (0V). The other range pushbuttons are mechanically interlocked.

c. Relay Operation.

1. Relay K503 (Zone B-3) connects INPUT HI to the nanovolt preamp input on 3mV DC and 30mV DC ranges. The relay is constructed with two coils; one of the coils is always energized.

2. Relay K502 (Zone G-4) connects the nanovolt preamp output to the A/D input (through CLAMP) when on 3 mV DC and 30mV DC ranges, where is is energized. The relay connects the CATT line to CLAMP when not energized on other DCV ranges.

3. Relay K501 (Zone H-5).

a) 300mV and 3V Ranges: K501 is not energized and connects CATT to DCV INPUT HI through overload protection resistors R523 and R524.

b) 30V through 1000V Ranges: K501 is energized and connects CATT to the output of the attenuator through R516.

d. DC Volts Zero Controls.

1. Potentiometer R509 (Zone L-3) is a 300mV Zero adjustment which develops a small current (< ±15 μA) through R511. The control is used to set AZ_2 (in DC V function) equal to the voltage at INPUT LO.

2. Potentiometer R513 (Zone F-7). The same circuit as used for 300mV zero is used to make the voltage at R507 equal to the voltage at Input LO on 30V DC range.

e. DC Attenuator.

1. Overload Protection. (R523, R524, R522, C503, in Zone H-4, H-5) On 300mV DC and 3V DC ranges if an overload is applied to Input HI, CATT will clamp at ± (4 to 7V). The remainder of the overvoltage will be dissipated in R523 and R524 which are mounted on a shield to the rear of the display board. R522 and C503 as well as C501 and C502 protect K501 from transients with a large V•Hz product.

2. 100:1 Ratio. (R515, R503, R505, in Zone G-5, F-5, and F-6) If Q501 is off, this is a simple 100:1 divider. The ratio is adjusted by R505.

3. 1000:1 Ratio. When Q501 is turned on (by control line H) a 1000:1 divider is formed by the ratio of R515 to the parallel combination of (R503 + R505) and (R504 + R506 + Q501 on resistance.) This ratio is independently adjusted using R506.

5-4. NANOVOLT PREAMP (Schematic 27937D and block diagram, Figure 22).

a. Input Filter. The preamplifier filter is a 2-stage R-C filter designed to withstand 250 rms sinewave or 250 v dc. Diodes CR601 and CR602 provide overload protection for the modulator stage that follows.

b. Modulator. The FET modulator (Q604) is a monolithic "Series-Shunt" chopper. Additional filtering is included to protect against fast-rise inputs and spikes generated by the chopping action. The "chopped" signal at the modulator output is a square-wave with an amplitude of $(V_{IN} - V_F)$ peak-to-peak.

c. AC Amplifier. The square-wave output is capacitively coupled to the ac amplifier by capacitor C609 and resistor R614. The ac amplifier consists of a differential FET pair (Q603) followed by operational amplifier U602. Fedback ac gain is nominally 1000, and is set by a feedback resistor newtork R612 and R613. DC gain is unity.

d. Demodulator. The ac output is direct coupled to the half-wave demodulator (FET switch Q602). The output of the demodulator is a square wave referenced to signal common and proportional to $(V_{IN} - V_F)$.

e. Closed Loop Gain. Overall dc gain is 100:1 and is adjusted via potentiometer R604. Components which determine the dc gain are resistors R604, R615, and R616.

f. Millivolt Zero. The zero circuit consists of 1 megohm resistor (R617), potentiometer R623 and a string of resistor divider taps R622 (A-P). The moveable jumper J601 is factory set for optimum zero span. The zero circuit generates a zeroing current through feedback resistor R616.

g. FET Driver Circuit. Complementary 520 Hz square waves are generated for driving Q604 A, B and Q602. Rise and fall times are tailored. Offset current is adjusted by means of potentiometer R603 which sets the rise time to the gate of FET Q604A.

h. The mV Zero circuit consists of 1 megohm resistor (R617) potentiometer R623 and a string of resistor divider taps R622A through R622P. The moveable jumper J601 selects zero span. The zero circuit generates a zeroing current through feedback resistor R616, which develops the compensating zero offset voltage at the input.

i. The oscillator and FET drive generates complementary 520 Hz square wave drives, with tailored rise and fall times, to drive the modulator and demodulator. Offset current is adjusted by means of tailoring the rise time to the gate of the series switch (Q604A) using R603.

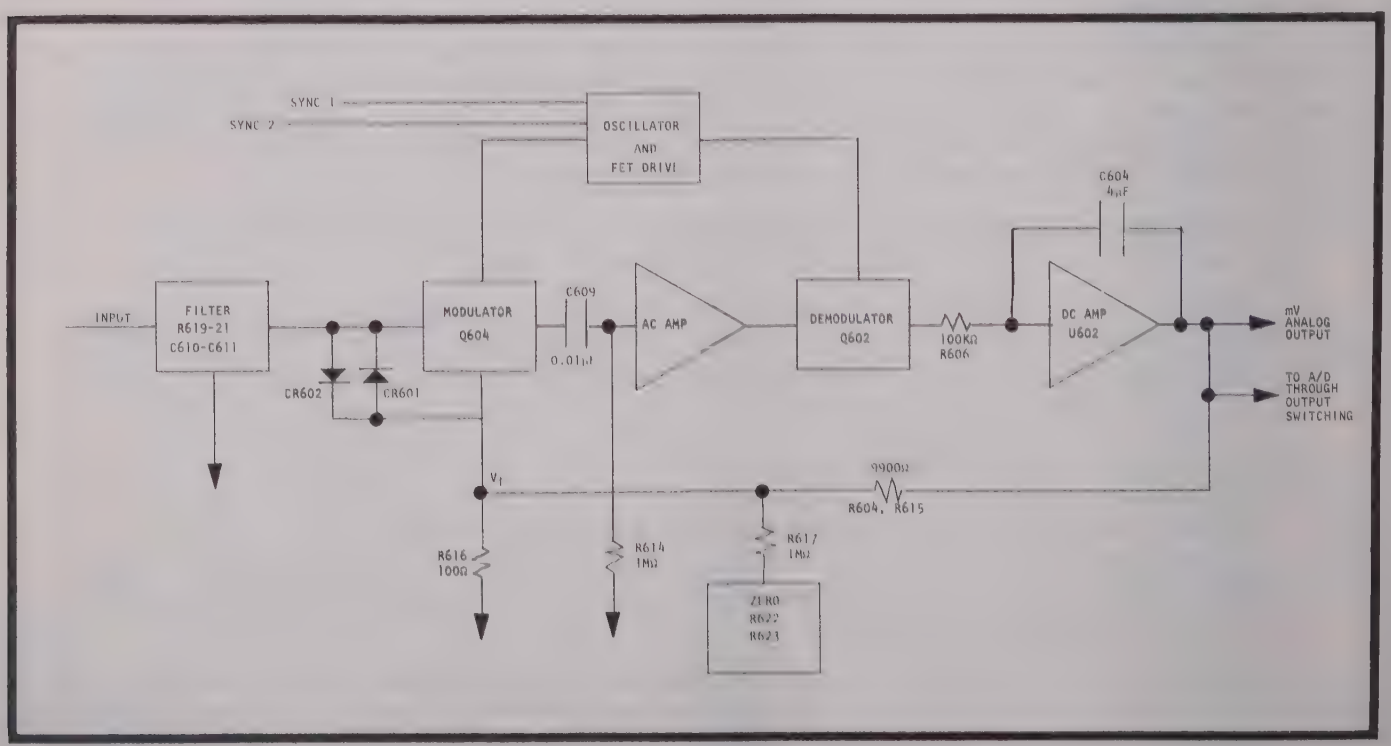


Figure 22. Simplified Diagram of Nanovolt Preamp.

5-5. MODEL 1740 AC OPTION.(Schematic 27944D).

a. Attenuator. The AC Attenuator divides down the input signal as necessary, after which the signal goes to the AC/DC converter and then to the A/D converter through the output switching.

1. The AC Attenuator shown in Figure 23 is a frequency compensated summing amplifier with maximum of unity gain. Amplifier gain may also be 0.1, 0.01, or 0.001, selected by relay K1201, K1202, or K1203 respectively. Table 5-2 shows the logical relationships between D10, D100, D1000, and range setting. Signals D10, D100, and D1000 are generated by the Digital Board (PC-421). These signals directly control relays K1201, K1202, and K1203.

2. FET Q1204 is "on" when using 30V, 300V, or 1000V ranges. FET Q1204 is "off" when using 300mV or 3 V ranges, therefore disconnecting 30V, 300V, and 1000V circuits from the summing junction of U1203.

3. C1224 blocks DC signals up to ±1000V, so that AC signals can be measured in the presence of DC voltages. The attenuator is referenced to -6 volts to keep the DC bias voltage on capacitors C1210 and C1211 near zero.

4. The gain of the attenuator is as follows:

$$A = \frac{-Z_f}{Z_{in}} = \frac{-R_f}{R_i}\left[\frac{1+j\omega R_i C_i}{1+j\omega R_f C_f}\right]$$

By making the RC time constant of Z_f equal to the RC time constant of Z_{in} (e.g. $R_iC_i = R_fC_f$), the gain of the attenuator is constant with frequency, and equal to $-Rf \div Ri$. This is true in the midband region. Low frequency response is limited by the RC time constant of C1224 and R1220, high frequency is limited by U1203.

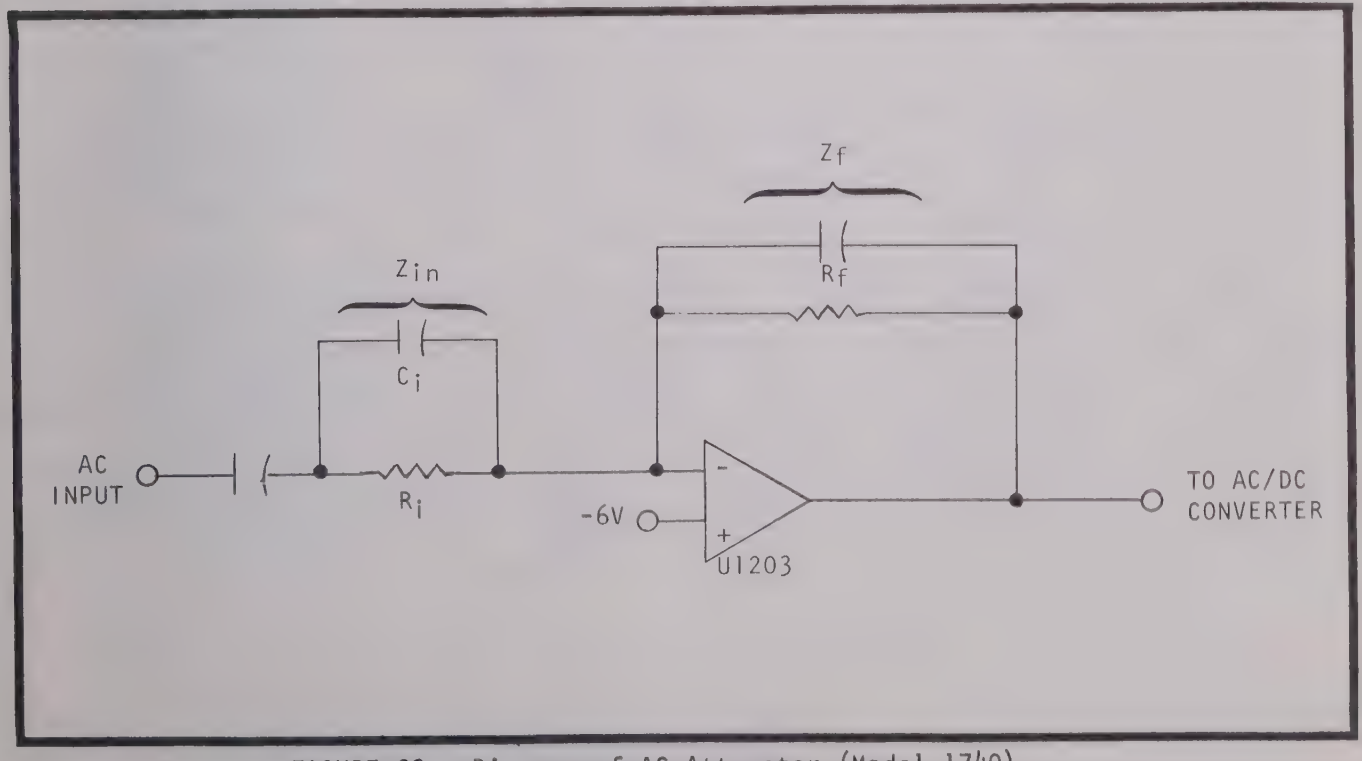


FIGURE 23. Diagram of AC Attenator (Model 1740).

5. Amplifier U1203 is powered from +3V (+15V-VR_{1204} voltage) and -15V. When the amplifier is overloaded, the average voltage at the output is -6 volts which keeps DC voltage off capacitors C1210 and C1211. This minimizes settling time when auto-ranging.

TABLE 5-2.
1740 Gain Chart.

RANGE	ATTENUATION	A/D GAIN	RANGE CONTROL LINES		
			D10	D100	D1000
300 mV	÷1	X10	0V	0V	0V
3 V	÷1	X1	0V	0V	0V
30 V	÷10	X1	+5V	0V	0V
300 V	÷100	X1	0V	+5V	0V
1000 V	÷1000	X1	0V	0V	+5V

b. AC/DC Converter.

1. The AC/DC converter is a transconductance amplifier. The simplified circuit shown in Figure 24 illustrates the basic operation. The AC input voltage (E_{in}) is converted to a current (I_{in}) as a result of the summing amplifier configuration. Current I_{in} flows through FET Q1201 when negative and through diode CR1201 when positive. Thus Eout is a halfwave rectified signal. Eout is developed by I_{IN} flowing through Rout. The positive (+) terminal of the converter amplifier is referenced to a negative voltage (-15V) to allow voltage swing across FET Q1201.

2. The AC converter consists of dual FET Q1203, operational amplifier U1201, MOS FET Q1201, diode CR1201, and transistor Q1202. The input resistance is determined by R1215 and R1212. The output resistance is determined by R1207 and R1201. FET Q1201 is located in the feedback loop of the converter amplifier. The gate of this FET is driven from the output of the amplifier for negative current input.

3. For positive input current the feedback path for U1201 and FET Q1203 (a, b) is through diode CR1201 and transistor Q1202. When the signal is positive at the input side of R1215, current flows into the summing junction of the amplifier, which is the gate of Q1203 (pin 3). This current causes the output of Q1201 to go negative. This turns on the base emitter junction of Q1202 and pulls current through diode CR1201, so that the connection path is through R1215, R1212, CR1201, and Q1202 (emitter to collector) to the -15V supply. The reason for using transistor Q1202 and not a diode is to equalize the output load on amplifier U1201 for each polarity, and to avoid parasitic oscillation which might occur in U1201, because of unequal output current loading.

4. When the input voltage is negative, current will flow out resistor R1212 and R1215, causing Q1201 output to go positive and forward bias Q1201 gate. This action turns on Q1201, pulling current through resistors R1207 and R1201 from signal ground. Thus Q1201 only conducts for negative input signals; the output current is a half-cycle negative going sinewave. This output current flows through C1201 and R1207 which provides filtering. The action of the filter allows a 3V output with only 6 volts available from Q1201. Without C1201 more than a 9 volt swing would be needed. The transfer gain of the AC/DC converter is unity. A one volt AC RMS sinewave input causes a 1 volt DC output.

5. Q1203 is a dual FET, used as source followers with source resistors R1213 and R1214. The 10mV adjustment feeds a small correction current to the summing junction to adjust for leakage current errors. The 1 volt (1 kHz) adjustment calibrates the system gain on the 300mV and 3V ranges. Additional output filtering is provided by the DC filter (whose input is R1206 and C1205 in this case.)

6. C1210 and C1211 are the only blocking capacitors needed on the AC/DC converter input. The capacitors keep voltage offsets produced by U1203, Q1203, and U1201 from reaching the output.

7. The AC/DC system common is the -6 volt reference. It is composed of voltage follower U1202 and input divider R1210 and R1211. C1206 is used to provide a low impedance AC path between -6V and signal low to minimize AC noise pickup.

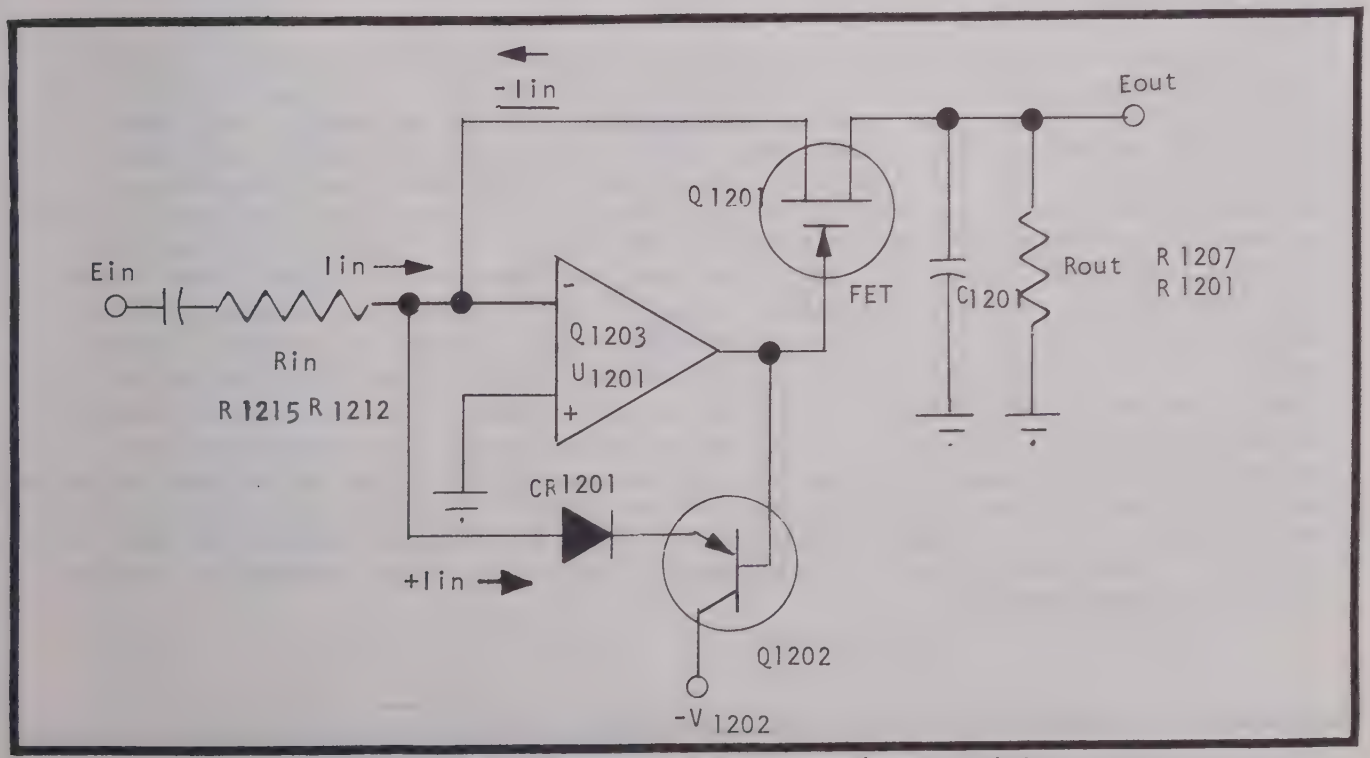


FIGURE 24. Diagram of AC/DC Converter (Model 1740).

5-6. MODEL 1744 OHMS OPTION. (Schematic 27941C)

a. Simplified Description. The basic philosophy for the Model 1744 ohms circuit is shown in Figure 25. A constant current equal to $V_{REF} \div R$ is forced through the unknown resistor R_X. The output voltage of the operational amplifier is proportional to the unknown resistor value and the value of the constant current. Properly scaled reference voltage (V_{REF}) and resistors (R) determine the value of the constant current which determines full range resistance sensitivity.

TABLE 5-3
Summary of Ohms Ranges

Range	HI OHMS						LO OHMS					
	V_{REF}	Full Range Volts at A/D Input	I_R	Range Logic A	B	C	V_{REF}	Full Range Volts at A/D Input	I_R	Range Logic A	B	C
300 Ω	-	-	-	-	-	-	3.3V	.3V	1mA	1	0	1
3KΩ	3.3V	3V	1mA	1	0	1	.33V	.3V	100μA	1	0	0
30KΩ	.33V	3V	100μA	1	0	0	3.3V	.3V	10μA	0	1	1
300KΩ	3.3V	3V	10μA	0	1	1	.33V	.3V	1μA	0	1	0
3MΩ	.33V	3V	1μA	0	1	0	3.3V	.3V	100nA	0	0	1
30MΩ	3.3V	3V	100nA	0	0	1	.33V	.3V	10nA	0	0	0
300MΩ	.33V	3V	10nA	0	0	0	-	.3V	-	-	-	-

b. Detailed Description.

1. A more detailed diagram of the ohms converter is shown in Figure 26. The measurement scheme is based on a "pseudo four-terminal" method. The four-terminal scheme is made possible by the four modes of operation of the A/D converter: AUTO ZERO 1 (AZ1), AUTO CALIBRATE (ACAL), AUTO ZERO 2 (AZ2), and SIGNAL INTEGRATE. AZ1 input is measured for 40 ms and this zero level is stored. During ACAL the A/D reference calibration voltage is measured for 40 ms. The A/D calibrates itself to the difference between A/D reference calibration and AZ1. Thus, it is calibrated to the voltage across R. Since R is a fixed, stable resistor, the value of I_R is now known. Since I_R also flows through R_X the calibration is fixed. AZ2 is measured for 40 ms. This is defined as the zero level for signal measurement and is stored in the A/D. The A/D measures the input at the bottom of R_X for 200 ms. The A/D thus measures the difference between signal input and AZ2 which is the voltage across R_X. This represents the value of R_X and is displayed after appropriate scaling. The measurement is essentially a ratio measurement between the voltage across R_X and the voltage across R. Notice that the voltage at the top of R_X is essentially at signal low of the instrument (±U1102 offset and lead resistance drop) and the voltage at the bottom of R_X is negative. Thus, the HI terminal is guarded and relatively fast response is achieved at high resistance values.

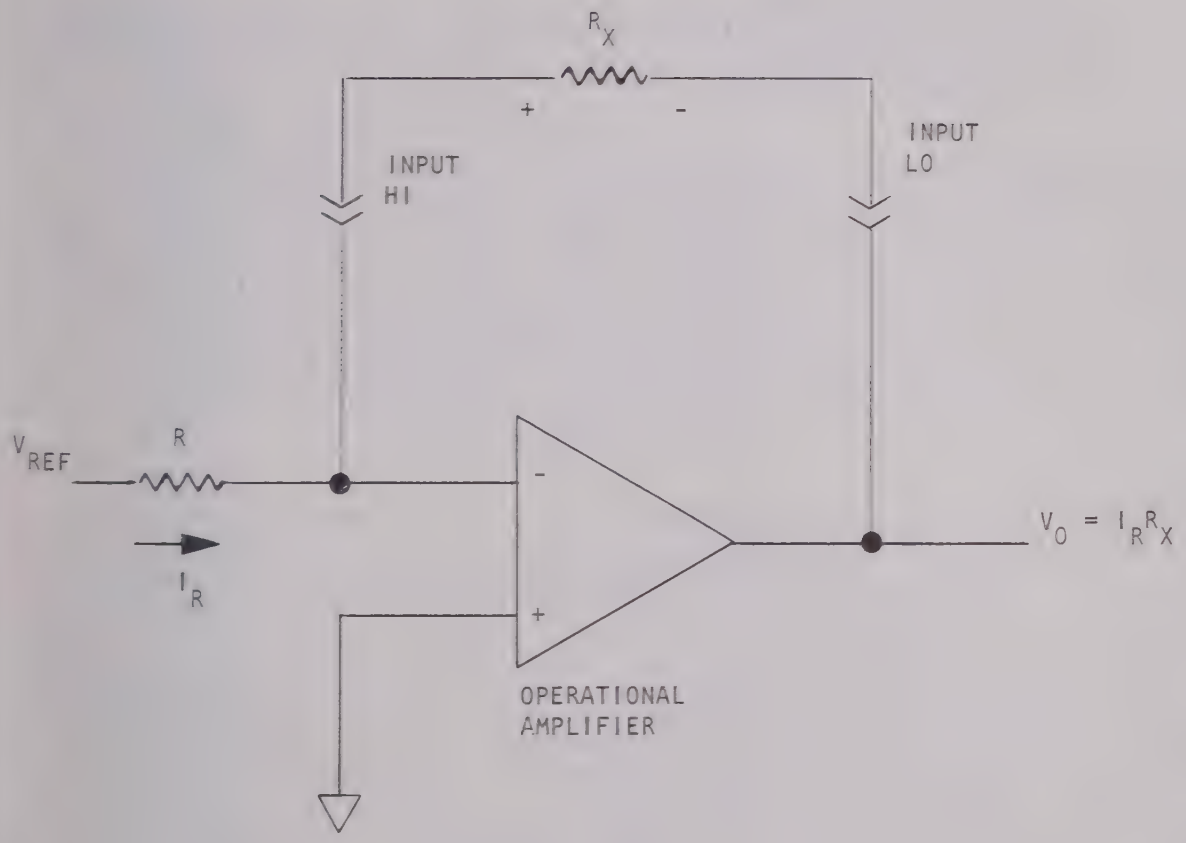


FIGURE 25. Simplified Diagram of Model 1744 Ohms Option.

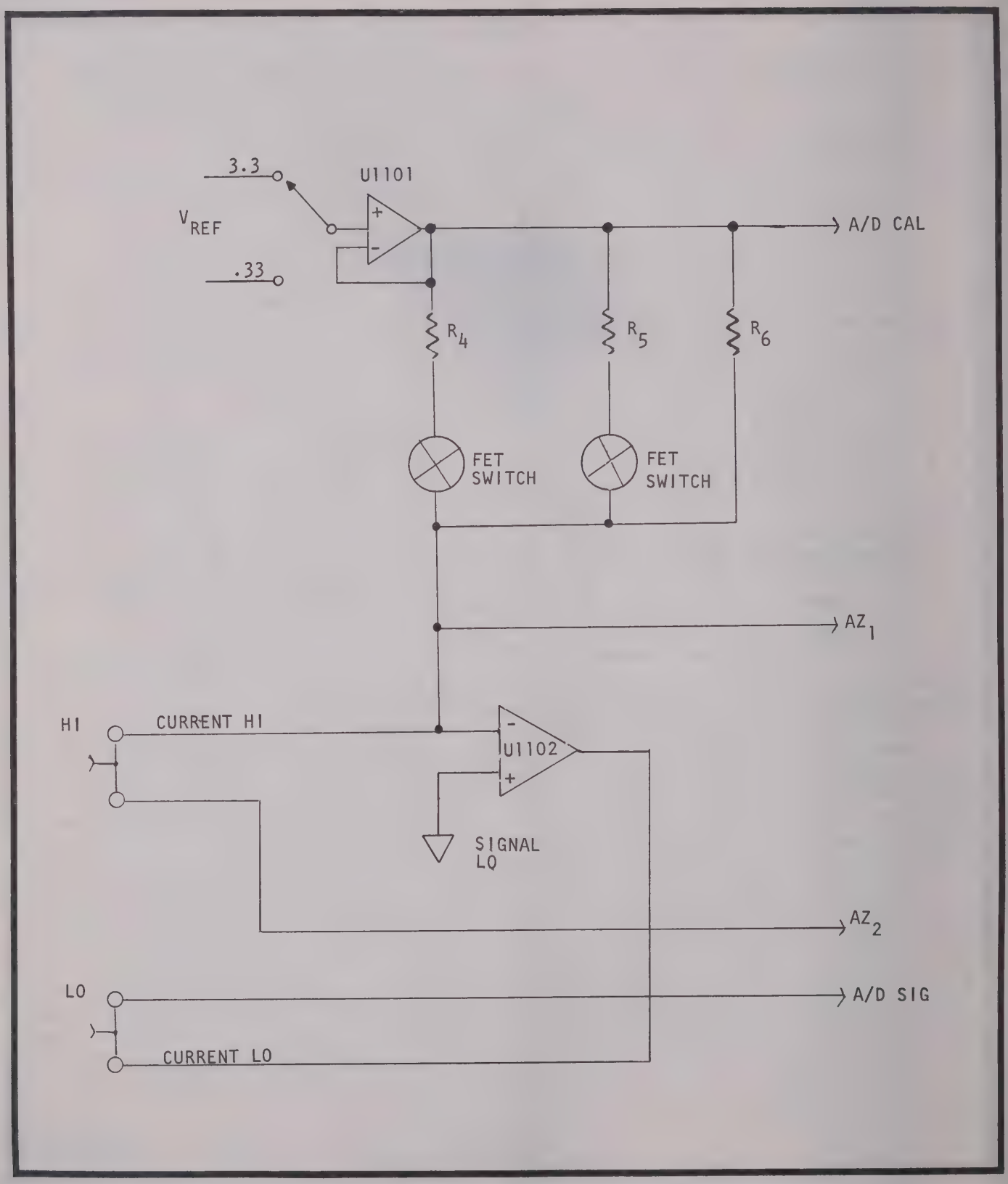


FIGURE 26. Detailed Diagram of Model 1744 Ohms Option.

2. The ranging is accomplished by selecting one of six current steps: 10nA, 100nA, 1μA, 10μA, 100μA, 1mA. Since the A/D Converter has ranges 0.3V and 3V, a total of 12 ohms ranges is possible.

3. Switching of V_{REF} is performed by FET switches Q1103 and Q1104. Range logic (A, B, C) is controlled by the U103. Switches Q1103 and Q1104 select either +3.3444 volts or +.33444 volts depending on the logic level of "C" (J1101, pin 2). Integrated circuit U1101 is a buffer.

4. Resistors R1102, R1101, and the "on" resistance of Q1101 make up what is called "R4" in Figure 26. Resistors R1103, R1105, and the "on" resistance of Q1102 make up what is called "R5" in Figure 26. Resistors R1104 and R1107 make up what is called "R6" in Figure 26. Notice that R_{REF} is the parallel combination of R_6 and R_4 or R_5 if they are switched into the circuit.

5. The operational amplifier is composed of integrated circuit U1102, current "mirror" Q1108 and Q1109, common-base transistor Q1107, and load resistors R1112 and R1113. U1102 is a differential FET input operational amplifier. Offset adjustment is provided by resistor network R1120, R1121, R1123, R1122, and R1106. The output of U1102 forces a current through resistor R1119, transistor Q1109 (connected as a diode), and resistor R1116. This current is then "mirrored" in the collector of Q1108. The base of transistor Q1107 is held at approximately -4 volts by the action of bias resistor R1114 and reference voltage of VR1101. Resistor R1115 is used for zener biasing. Capacitor C1102 decreases output noise and assures loop stability.

6. The diode CR1102 from the junction of R1112 and R1113 limits the amount of power delivered to them and the current injected to the +15V supply under overload conditions. R1112 and R1113 determine open circuit voltage at the input terminals. The diode CR1103 in the collector of Q1107 is likewise for overload protection and keeps the base-collector junction of Q1107 from ever being forward biased, as this could cause too much current to be drawn through R1114 and R1115. Q1110, CR1106 and Q1111 protect U1102 during overload as seen in Figure 26.

7. When the ohms circuit is functioning properly, and an open circuit condition exists, an alternate feedback loop comes into play, thus keeping the AZ_1 point near ground. Q111 in conjunction with R1118 and Q1106 provide for this. When the input terminals are open circuited, the output of U1102 starts going positive, increasing the current through Q1109 which is mirrored in Q1107. Since the collector current to Q1107 is limited, additional base current in Q1107 flows through its base resistor R1114, turning on Q1106 which pulls current through Q1111 keeping the AZ_1 point near ground.

5-7. MODEL 1745 AMMETER OPTION (Schematic 27940C). The shunt resistors are switched by the range pushbuttons (S301) and are arranged in a four-terminal measuring scheme. The A/D converter sensitivity is 300 millivolts full range. On the 300 µA through 3A ranges the input is protected by a 4 ampere fuse (F1001), and by diode bridge CR1001 which clamps the input to 2 diode drops for either positive or negative inputs. Unity gain amplifier U1001 guards the center connection of the diode bridge.

TABLE 5-4
Summary of the Model 1745 Ranges

Range	Shunt Resistance	Cal Adjustment	Input Pin	Current Protect Circuit Active
3µA	100KΩ	R1001	J1001, pin 1	NO
30µA	10KΩ	R1002	J1001, pin 2	NO
300µA	1KΩ	R1003	J1001, pin 3	YES
3mA	100 Ω	R1004	J1001, pin 4	YES
30mA	10 Ω	R1005	J1001, pin 5	YES
300mA	1 Ω	R1006	J1002, pin 1	YES
3 A	0.1 Ω	R1007	J1002, pin 2	YES

5-8. ANALOG-TO-DIGITAL CONVERTER. (Schematic 27936F)

a. Introduction.

1. The A/D converter, as its name implies, performs the function of generating a digital representation of an analog voltage applied to its input. The basic functional blocks involved in this process are shown in Figure 27. This A/D converter has several distinct modes of operation, broadly grouped as "signal-measurement mode" and "error-correction mode". It can be seen that the transformation from voltage input to display output occurs in two major blocks. The first block (V/F Converter) generates a digital pulse train whose frequency is proportional to the input voltage. The second block (digital chip) contains circuitry which counts the incoming pulses for a fixed time period, producing a total count which is proportional to the average of the input voltage over that time period.

2. The digital chip (a custom MOS LSI circuit) which performs the pulse counting function also performs a number of other functions necessary for the analog-to-digital converter, and for other portions of the DMM. Details of the operation of this digital subsystem will not be given in the following discussion. However, various of its outputs which are necessary for the operation of the remainder of the A/D converter will be referred to when necessary.

3. The first step of the A/D conversion process, the Voltage-to-Frequency conversion, is performed using a principal known as charge balancing. The resulting output pulse train has the property that its average frequency over a given time period is proportional to the average of the input voltage over the same time period. Thus, the charge balance technique has the property that the digital output is a representation of the true integral of the analog input over any specified sampling time. The circuitry which performs the V/F function is explained in detail in Section 5-8b.

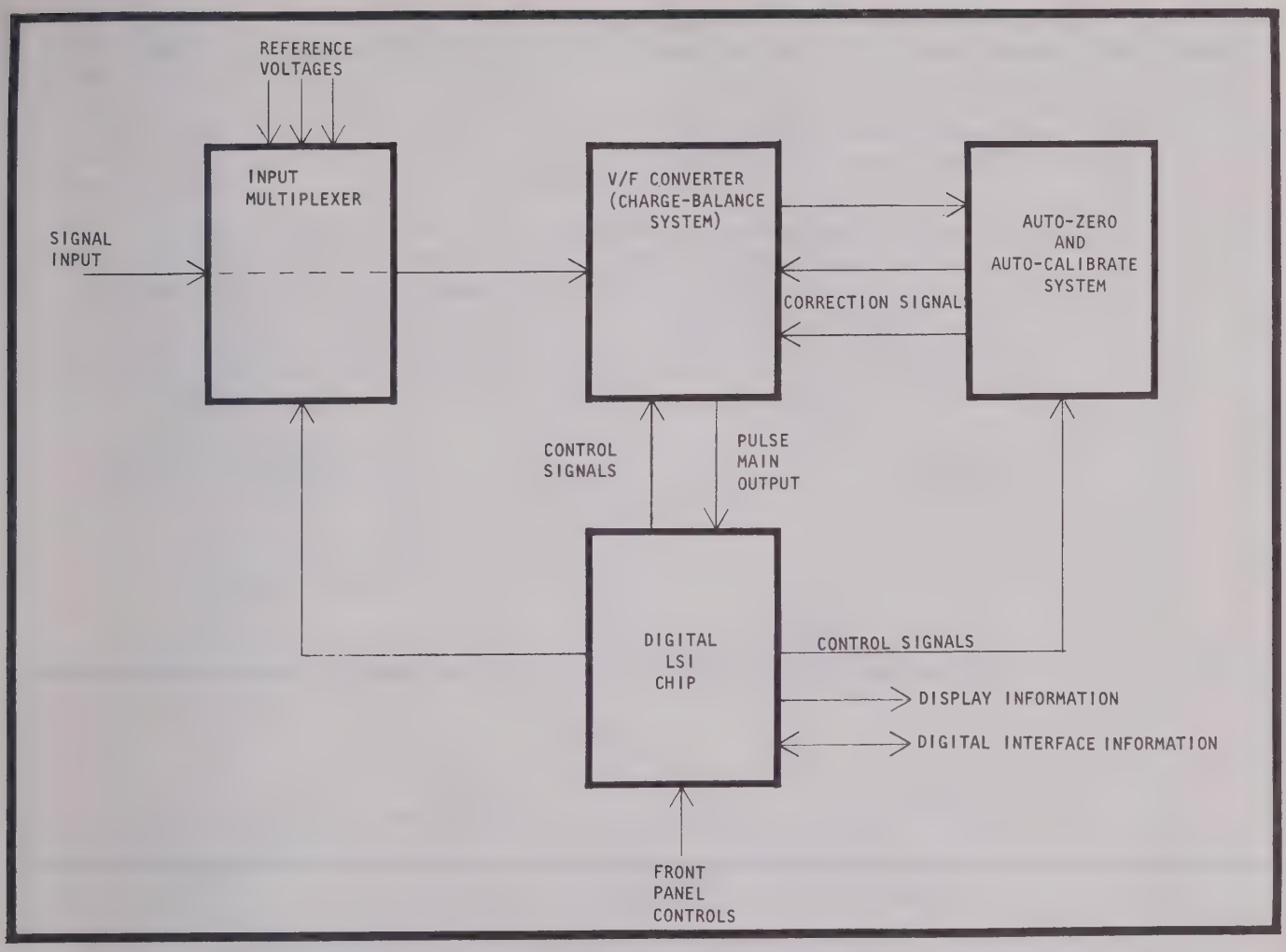


FIGURE 27. Basic Functional Blocks of A/D Converter.

4. The charge-balance circuitry described in Section 5-8b, although highly linear, has certain intrinsic scale factor and zero offset errors. In the complete A/D converter these errors are corrected for by the use of additional circuitry. This so-called Auto-Zero and Auto-Calibrate circuitry is described in Section 5-7c. Section 5-7d contains a description of overall A/D converter system operation, combining the circuit functions described in sections 5-7b and 5-7c into a complete A/D conversion cycle.

b. Voltage-to-Frequency Converter.

1. The simplified circuit shown in Figure 28 illustrates the basic principles of the charge-balance V/F converter. Its operating waveforms are shown in Figure 29. Assume the integrating capacitor voltage, V_i, to be initially negative. As the input signal current I_X is integrated by the capacitor, V_i rises and eventually becomes more positive than the threshhold of the comparator (time t_1 in Figure 29). The comparator output voltage V_C, which is a logical variable, then rises to a logic 'one'. At the next positive-going edge of the clock C1D (time t_2 in Figure 29), this 'one' is latched by the flip flop and appears as the latched output QR. At t_3, the out-of-

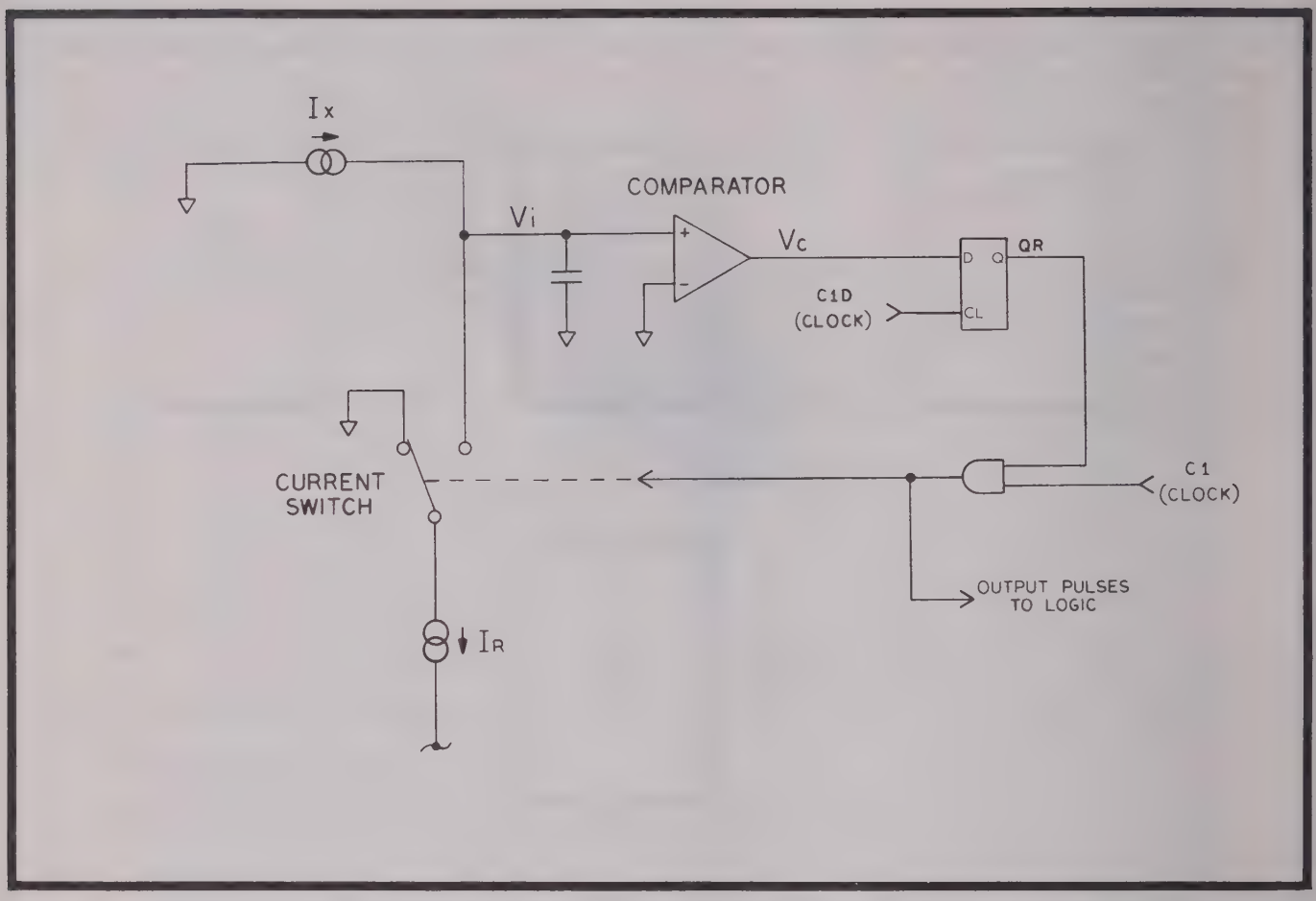


FIGURE 28. Basic Charge-Balance Converter.

phase clock, C1, goes high and enables the output of the AND gate, thereby turning on the current switch. For the next half clock period, from t_3 to t_5, the reference current I_r is forced to flow out of the integrating capacitor, discharging it and bringing V_i to a negative value. Sometime (t_4) during this reference current pulse, V_i crosses the comparator threshhold in a negative direction and V_c goes to a logical 'zero'. At the next positive-going edge of clock C1D, (t_6), the comparator voltage V_c, is still a zero and therefore the flip flop output also becomes a zero. The reference current consequently is not turned on during that clock period, and in fact stays off until the next time the integrator voltage once again rises above the comparator threshhold.

2. For relatively large values of the input, the time required for the integrating capacitor to be recharged above the comparator threshhold is relatively small, and the charging-discharging cycle described will occur at a high frequency. For lower values of input current, the recharging time of the integrator will be correspondingly longer and the events described will occur at a lower rate. Thus the repetition rate of reference current pulses (and digital output pulses) is a function of the input current.

3. Notice that the amount of charge removed from the integrating capacitor during each discharge cycle is equal to the product of the reference current, I_r, and one-half the clock period. Since the total charge removed from the capacitor in any given time period is equal to the total charge that flowed in during the same time period (within a resolution of one discharge increment) the uniformity of size of the reference current pulse guarantees that the total number of such pulses is precisely proportional to the time-integral of the input current.

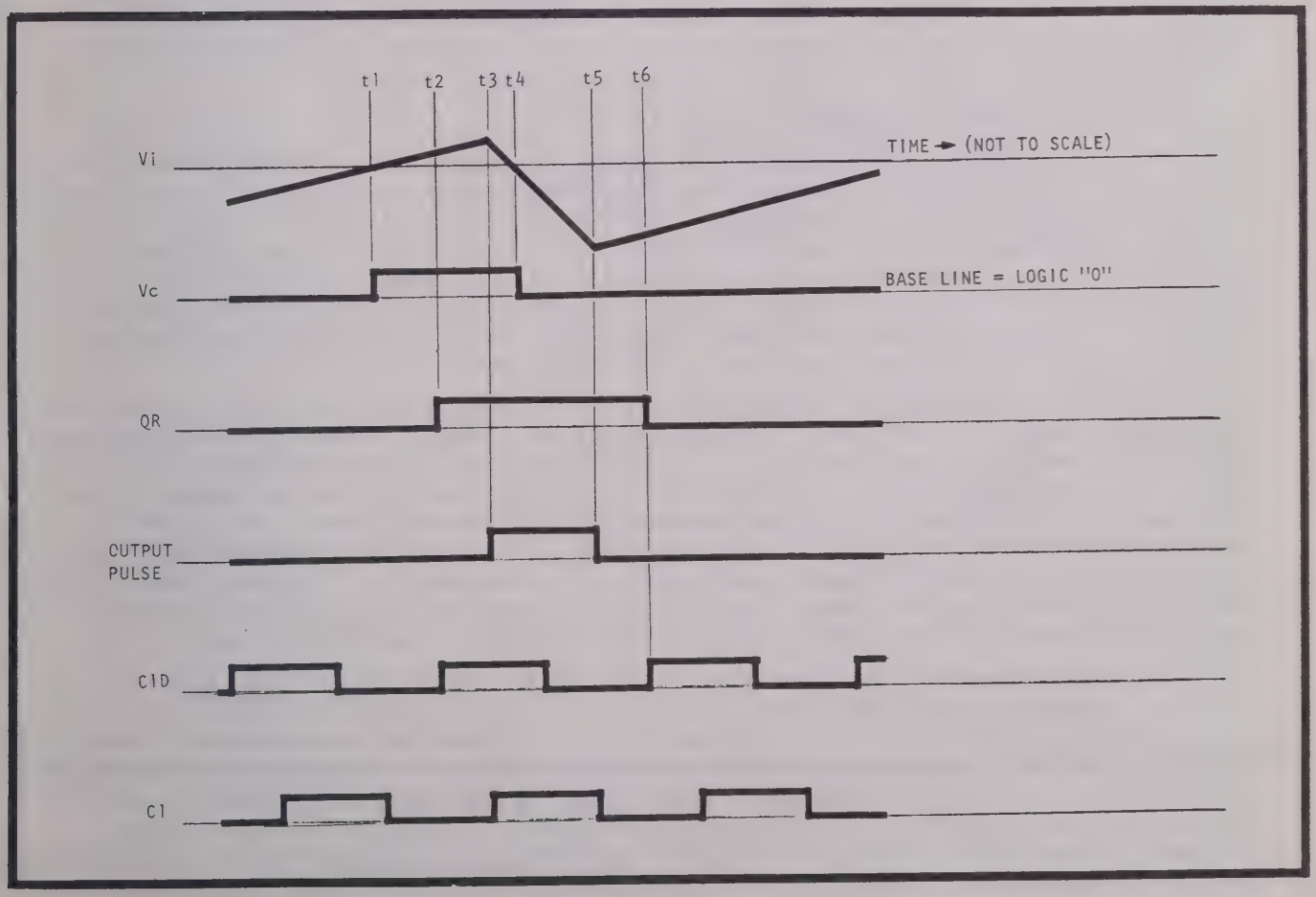


FIGURE 29. Operating Waveforms of A/D Converter.

4. Figure 30 is a simplified schematic diagram of the circuitry actually employed to perform the V/F conversion. In addition to some added details of the circuitry already discussed, Figure 30 shows three major circuit elements not previously mentioned.

a) The input buffer amplifier, U202, serves two functions. First is provides a high impedance input to the A/D converter. Second, it provides a selectable voltage gain of 10, giving the A/D converter in effect two voltage ranges, selected by the line labeled G10 (an output from the LSI chip).

b) The transconductance amplifier, consisting of op amp U101 and its associated MOS FET (Q104) and resistors, converts the voltage which appears at the output of buffer amplifier U202 into a proportional current, I_X, which is used to charge the integrating capacitor.

c) The reference diode and the resistor connected from it to the summing junction of op amp U101 provide a fixed current component of I_X, in addition to the variable component I_S (which is proportional to the input voltage). This fixed offset current, labeled I_O, allows the overall A/D converter to handle both positive and negative input voltages. With this arrangement, the output pulse frequency is one half of its maximum possible value when the input voltage to the entire converter is zero. This transposition is accounted for in the digital subsystem (LSI chip) by subtracting a fixed number from the accumulated count before displaying it.

d) The remaining circuitry in Figure 30 is functionally equivalent (with some added details) to the basic charge-balance loop shown in Figure 28. The digital output signals QR and CLK are used by the digital subsystem, in effect, to reconstitute the pulse train discussed in connection with Figure 29.

c. Auto-Zero and Auto-Calibrate Circuitry.

1. The charge balance system shown in Figure 28 is inherently highly linear, but both its zero and full-scale calibration (scale factor) are susceptible to drift with time and temperature, due to a variety of effects. Through the use of a pair of related circuit functions, referred to as Auto-Zero and Auto-Calibrate, these intrinsic errors can be cancelled, resulting in a system whose scale factor is essentially as stable as the voltage of a reference zener diode and whose zero stability is limited principally by thermo-electric offsets. The techniques used to achieve this performance are described in this section.

2. It can be shown that all zero-error sources in the charge balance system (such as offset voltage drift of amplifiers U202 and U101, input current drift of amplifier U101, etc.) can be represented as a total effective error current at the summing junction of amplifier U101. In a similar way, all gain errors are equivalent to an error current at the emitter of the reference current output transistor, Q102B. It is thus possible to correct for all such errors by introducing an appropriate correction current at each of these two locations in the circuit. The function of the Auto-Cal and Auto-Zero circuitry, then, is to discover the proper values of these two currents and to supply them during the measurement of the input signal.

3. The method used to "discover" the proper value of the correction signals is as follows: Consider first the Auto-Zero operation. In an error-free system, a zero-volt input would cause the charge-balance loop to deliver reference-current pulses to the integrator at exactly 1/2 the clock frequency (see Section 5-7b4c). In the Auto-Zero mode, the buffer input is supplied with zero volts, and the current switch is digitally forced to deliver reference-current pulses at precisely 1/2 the clock frequency. The current being delivered to the integrator through the transconductance amplifier (I_X) does not exactly match this forced reference current; the difference

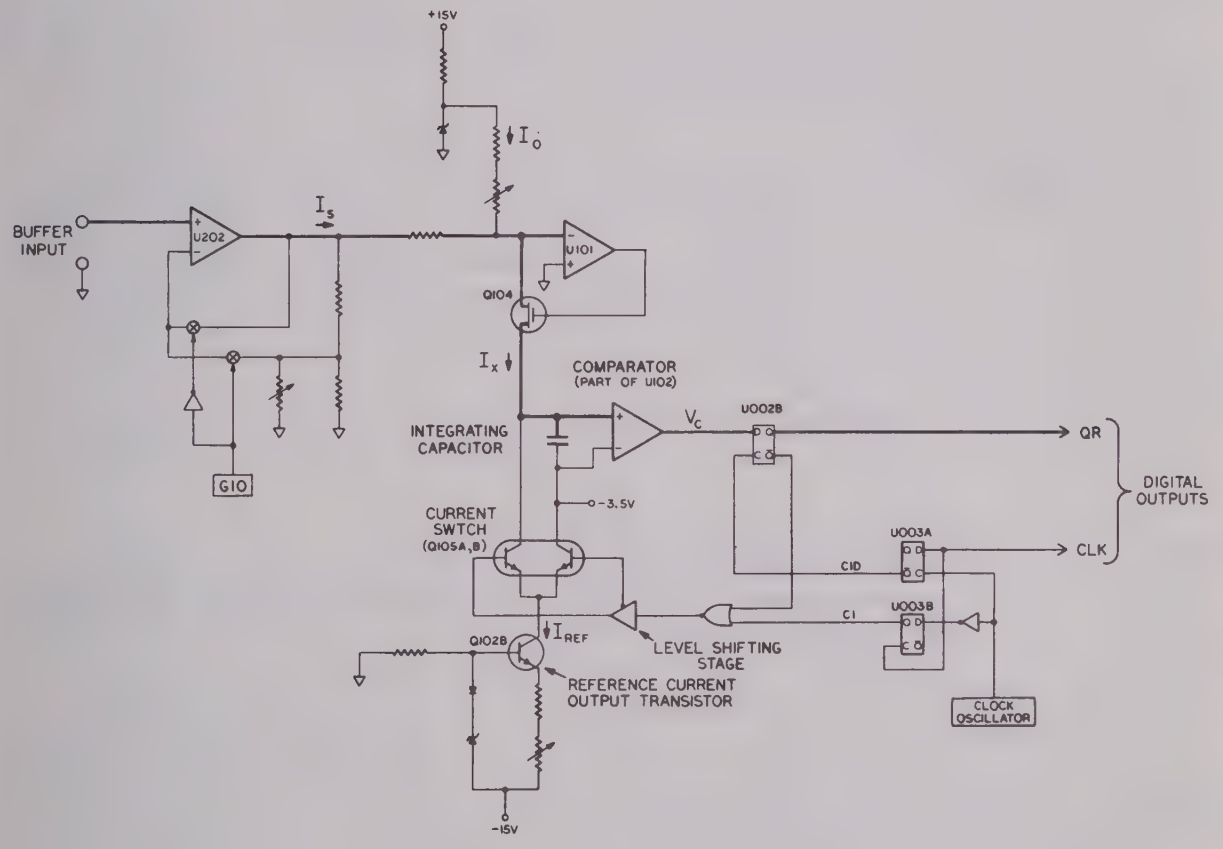


FIGURE 30. Simplified Schematic.

exactly equals the correction current required to cancel the offset errors. Thus the integrator voltage, V_i, exhibits a charge balance sawtooth waveform like that shown in Figure 29, superimposed on a much slower ramp whose slope is proportional to this difference current. The auto-zero feedback system adjusts a correction current which flows into the summing junction of amplifier U101 so that the slope of the ramp is equal to zero. In this way, all zero errors are precisely cancelled.

4. The Auto-Calibrate system works in an analogous manner, with three differences of detail:

a) The voltage supplied to the input of buffer amplifier U202 is the exact amount voltage which the charge balance system can measure.

b) The current switch is forced to a frequency equal to the clock frequency rather than one half of it.

c) The feedback correction current is delivered to the emitter of the reference current output transistor (Q102B).

5. The circuitry which performs the operations described above is shown in Figure 31, together with most of the charge balance system redrawn from Figure 28. The added circuitry is grouped in five major blocks:

a) Input Multiplexer,

b) Reference current forcing circuitry,

c) Comparator filter,

d) Auto-Zero feedback and storage circuitry,

e) Auto-Cal feedback and storage circuitry.

6. This circuitry will be described block by block with reference to the above description of its basic mode of operation.

a) The input multiplexer supplies the necessary "known" voltages to the input of the buffer amplifier at appropriate times, and connects the buffer amplifier to the signal source when that signal is to be measured. The multiplexer consists of JFET switches controlled by signals from the LSI chip. The two adjustable capacitors shown in Figure 31 are used primarily to neutralize the JFET switching charge in order to minimize the A/D input current.

b) The reference current forcing circuitry controls the input of the comparator latch flip flop. In the Auto-Zero mode, it forces the output of this flip flop to alternate between one and zero on successive clock periods. The resulting reference current pulse rate is equivalent to an output frequency from the charge balance system of 1/2 the clock frequency. In the Auto-Calibrate mode QR is forced to a one constantly with the result that the reference current is on at every opportunity; reference-current pulse frequency thus equals the clock frequency. Two chip outputs, FON and COFF, are used to control these two operating modes: FON is a logic "1" during both Auto-Zero and Auto-Calibrate, and COFF is a logic "0" during Auto-Zero and "1" otherwise.

c) The block labeled "Comparator Filter", not previously mentioned, serves an important function in the Auto-Zero and Auto-Calibrate feedback loops. As discussed above, the component of the integrator voltage which is of interest for Auto-Zero and Auto-Cal purposes is the slow ramp arising from the effective error currents. Because this ramp has superimposed on it a relatively high frequency triangle waveform, the combination of comparator and comparator-filter functions as a switching-

mode (class D) amplifier for the ramp voltage, with gain equal to the ratio of the V_C switch to the triangle amplitude. The comparator-filter's function is to smooth the switching output of the comparator so that only the low-frequency amplified ramp signal is passed on to the remainder of the Auto-Zero (or ACAL) feedback loop.

d) The Auto-Zero feedback and storage block completes the control loop used to generate the Auto-Zero correction current. Ignore for the moment the two storage capacitors and consider only the direct signal path via the Auto-Zero loop switch and the JFET source follower. Consider the following circuit elements: Transconductance amplifier, integrating capacitor, switching mode amplifier (comparator and comparator filter), auto-zero loop switch, source follower and the resistor between FET source and U101 summing junction. Examination shows that these circuit elements constitute a simple low-frequency and dc feedback loop which will strive to adjust the voltage across the integrating capacitor to a value near zero. Once this condition has been achieved, then the Auto-Zero correction current I_{AZ} must have taken on the desired value, since the total current being fed to the integrating capacitor must now be exactly balanced by the switched reference current.

The remainder of the auto-zero system operation is quite simple. Once the stable closed loop condition has been achieved, one of the two capacitor switches is then closed and the gate voltage on the source follower (which has the value necessary to produce the correct value of I_{AZ}) is stored on that capacitor. When the loop switch finally opens at the end of the Auto-Zero phase, the value of I_{AZ} which was established during the Auto-Zero phase thus remains in effect until the next Auto-Zero operation.

e) The Auto-Cal feedback and storage block works in a manner identical to that of the Auto-Zero feedback and storage block, with the exception that its output current is fed to the emitter of Q102B instead of the summing junction of U101. Although the Auto-Zero and Auto-Cal correction operations interact to some degree, a few sequential iterations of these operations suffice to establish the correct values of the two correction currents.

d. Overall A/D System Operation.

1. In the preceeding two sections the structure and function of each major analog circuit block has been explained. This section contains a description of the manner in which these elements are combined in a complete A/D conversion. The description is based on Figure 32, an overall A/D converter timing diagram showing one complete conversion.

2. The first major division of the conversion period is into an error-correction segment (120 ms long) and a signal-measurement segment (200 ms long). During the former, the input multiplexer supplies known reference voltages to the V/F block, and (as described in Section 5-7c) the correction currents I_{AZ} and I_{ACAL} are established. During the latter, the now error-corrected V/F converter has the unknown signal voltage applied to its input, and its output pulses are counted by the digital chip. (As the next conversion period begins, the chip processes the resulting pulse-count and displays the result.)

3. The error-correction segment of the conversion cycle is further divided into three 40-msec. phases. During the first two of these phases, the buffer amplifier gain is held constant at either 1X or 10X (depending on DMM range and function). During the AZ1 phase, the input multiplexer supplies the buffer with a zero-reference voltage, and the Auto-Zero feedback loop is closed. The value of I_{AZ} required to correct any system zero-errors is established, and the closure of the AZC1 switch (see Figure 31) causes the source-follower gate voltage which produces this current

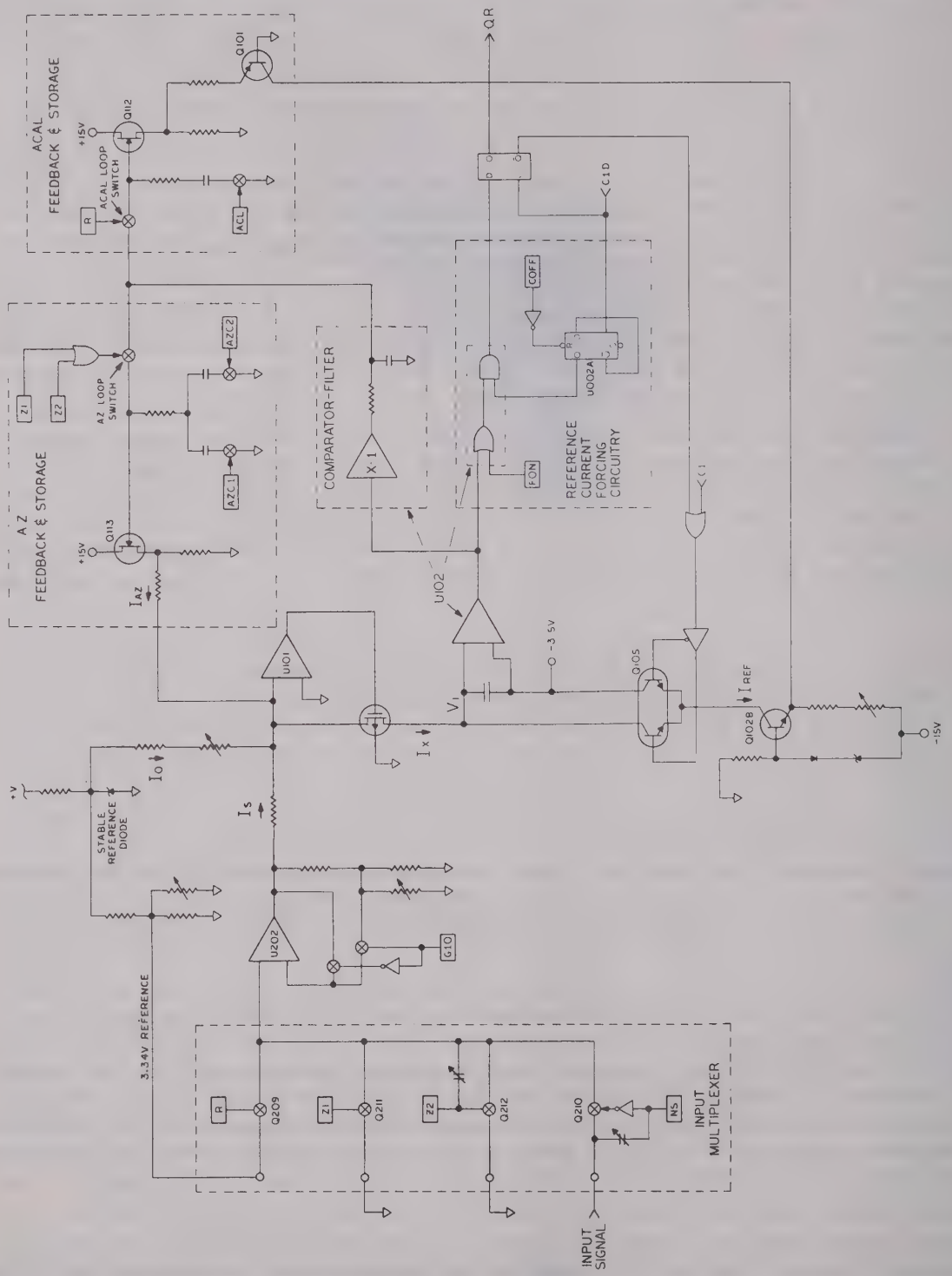


Figure 31. Simplified Diagram of Complete A/D Converter

to be stored on the corresponding Auto-Zero storage capacitor.

4. During the ACAL phase, the multiplexer connects the buffer input to a full-scale reference voltage (either 3.34 or 0.334V, depending on buffer gain), and a similar process results in a scale-factor correction voltage being stored in the Auto-Cal storage capacitor.

5. Buffer gain during the AZ2 phase is always the same as it is during the signal-measurement phase; it may differ from its value during AZ1 and ACAL. Because of the (possibly) changed buffer gain, the effective system offsets may have changed so the second Auto-Zero operation is required to prepare the V/F converter for an error-corrected signal measurement. This new value of the Auto-Zero correction voltage is stored on the capacitor controlled by the AZC2 switch (Figure 31).

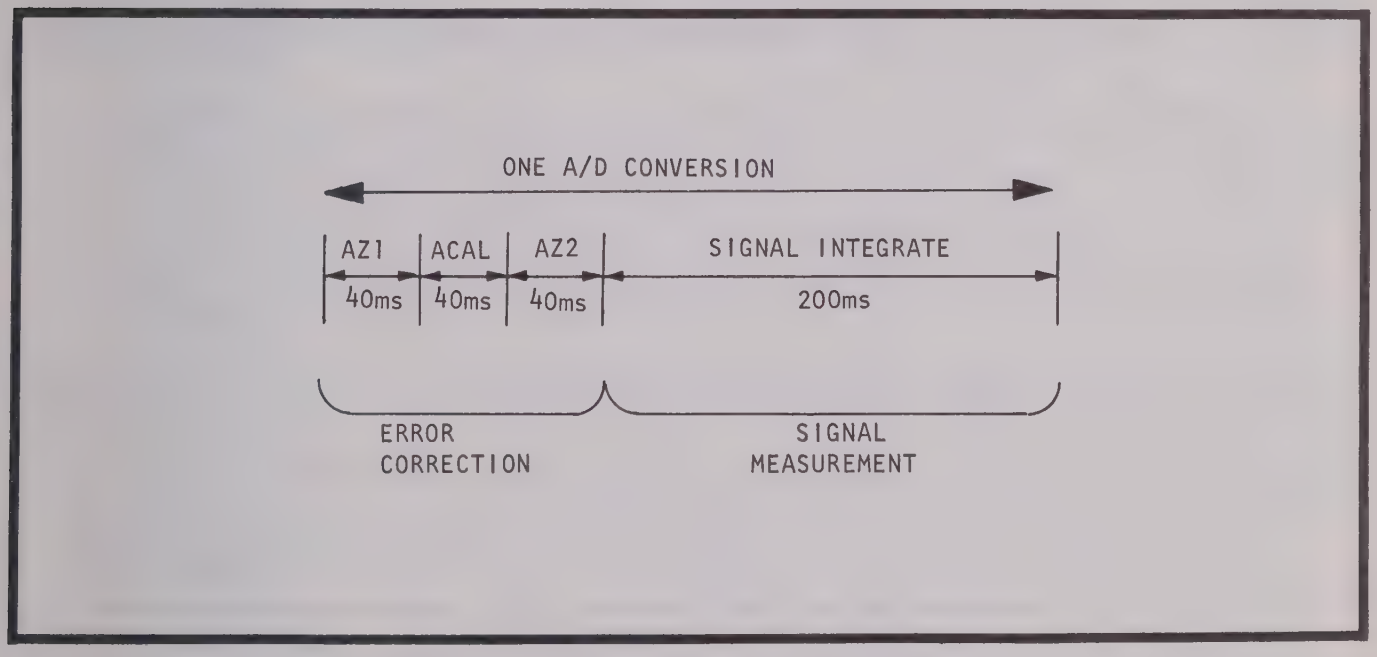


FIGURE 32. A/D Converter System Timing.

5-9. DISPLAY BOARD (Schematic 27939D).

a. This schematic shows the display digits, the LED function indicators, all display drivers, and timing mux generator. The entire display, including (polarity) sign and function indicators are fully multiplexed. This is accomplished with six time slots (timing mux). The "mux" times are generated by shift register U801. Inputs to U801 are generated by LSI U103 (Schematic 27936F). The time slots are identified at t_0, t_1, t_2, t_3, t_4, and t_5. The common anodes of the digits and function indicators are driven by the appropriate "mux" line. The "mux" timing is also used with the Model 1722 or 1723 digital interfaces. The total "mux" cycle is 1.53 milliseconds. Periods t_2 through t_5 are 191.5 microseconds, while t_0 and t_1 are twice as long (383 microseconds).

b. The data "mux" lines drive the cathodes of the display segments (a,b,c,d,e,f,g,dp) and function indicators. The data "mux" signals are generated by U103.

c. The t_1 period controls the 10^4 digit and the polarity sign. To keep constant brightness compared to other digits the data "mux" lines are activated for one half the t_1 period or 191.5 microseconds. The 10^4 digit is blanked unless it is a 1, 2, or 3.

d. The anode driver transistors are saturating switches (Q810 through Q815). The segment driver transistors are emitter followers (Q802 through Q809). The current limiting resistors are R802A through R802H. Segment current is approximately 30 milliamperes peak. Resistor R803 and capacitor C802 decouple current spikes from the 5 volt supply. Capacitor C801 decouples integrated circuit U801 from the power supply. Diode CR801 and resistor R808 prevent parasitic oscillation of segment driver transistors.

e. Pin 15 NBI line will turn on all decimal points when the function selected is not installed. Q801 and R804 accomplish this when the appropriate option is not installed; Q801 is turned on by R804.

TABLE 5-5
Display Data MUX Lines.

SEGMENT LINES	DRIVES DISPLAY SEGMENT OF INDICATOR LIGHT DURING					
	t_5	t_4	t_3	t_2	t_1	t_0
a	a	a	a	a	a for last ½ of t_1, Off other half	mV indicator
b	b	b	b	b	b for last ½ of t_1, Off other half.	V indicator
c	c	c	c	c	c Same as above.	µA indicator
d	d	d	d	d	d Same as above.	mA indicator
e	e	e	e	e	e Same as above.	A indicator
f	f	f	f	f	NOT USED	Ω indicator
g	g	g	g	g	g for last ½ of t_1 Off other half	kΩ indicator
dp	dp	dp	dp	dp	"-" indicator All of t_1	MΩ indicator

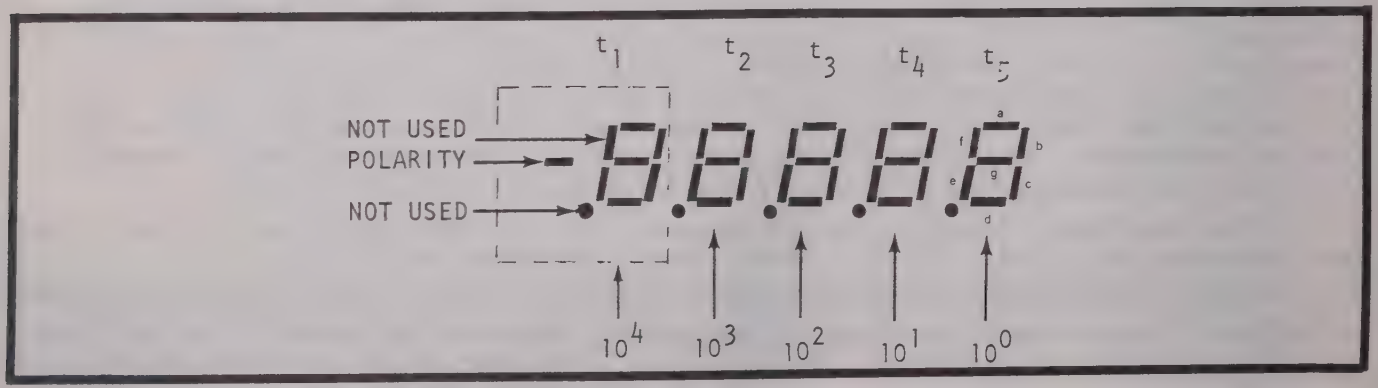


FIGURE 33. Digital Display Multiplex Scheme.

5-10. DIGITAL BOARD (Schematic 28209E).

a. Circuit Partitioning on Schematic 28209E.

1. Relay Drive Circuit. This circuit is located from Zone A to Zone H, not including J702 (pins 10, 8, 1, 4), P701 (pins C, B, A), J705 (Pin 2), or J704 (Pin 5).

2. Interface Logic. This circuit is located from the right edge of the relay drive circuit to Zone K, not including Q722, Q719, or Q720.

3. Phase Lock Loop Circuit. This circuit is located on the remainder of the schematic.

b. Detailed Circuit Description.

1. Relay Drive Circuit. This circuit develops relay drive signals (J704, pins 1, 3, 4, 8; J705, pins 9, 8, 6, 3, 4, near the top of the schematic). Logic inputs are from connector J704, pins 2, 6; J705, pins 7, 10; J702, pins 3, 7, 6, 2 (near the bottom of the schematic).

a) Logic Outputs D1000, D100, D10. These signals are HI-true drive lines for relays on the Model 1740 AC Volts Option. Logic is derived from the "V1" line (J702, pin 7) which is a signal determined by the Function Switch setting, "RL" line (J702, pin 3), "H" line (J705, pin 7), and "G10L" line. "G10L" is buffered and is derived from A/D Line "G10" of U103. "G10" controls the 300mV or 3V A/D sensitivity at certain portions of the A/D conversion cycle. "NAZC2" clocks the flip-flop U705B during the time when "G10" is valid. Thus, "G10L" remains valid until "NAZC2" updates "G10L" (during the next conversion).

b) Logic Output ACS. This signal turns on transistor Q1204 (located on Model 1740 AC Option) when on 30 VAC, 300 VAC, or 1000 VAC ranges. Transistor Q712 is on when "RL" is "LOW".

c) Logic output NH3V: A "LOW" state forces the A/D to 3V sensitivity regardless of "G10L" state, in particular, on 30 V range the A/D is set to 3V sensitivity. Logic is performed by U706C, U709A, U711A, and U707A, D. Input signals used are "G10L", "ACDC", "RL", and "N3VR5" ("N3VR5" is always pulled up by R744).

d) Logic Output NATTRL: This signal drives relay K501 which is part of the dc attenuator. Logic is the complement of "RL" from U103.

e) Logic Output NVPARL: This signal turns on relay K502 (Q707 turns on) when on the 3mV DC and 30mV DC ranges. Logic is performed by U706B using "RL", "H", and "V1" lines as inputs.

f) Logic Outputs NSET and NCLEAR: "NSET" is active on the 3mV DC and 30mV DC ranges only. "NCLEAR" is active on all other ranges and functions. When active, transistors Q708 or Q717 saturate and connect either "NSET" or "NCLEAR" to -12 volts (VR701). Transistors Q703 and Q702 drive transistors Q708 and Q717 respectively. Logic is performed by U706B (as for NVPARL). U712A generates a complementary signal for Q702 and NSET.

2. Interface Logic. This circuit controls range selection through the serial input to U103 (SERDAT line, Zone I-1).

a) U703 is a bilateral switch (4 in parallel) which selects between range control information from either the Model 1722 or 1723 (on SDAT, Zone H-3), or range control information from the front panel through shift register U708 (Zone J-7), U701 timing logic (Zone I-5) and Q711, which drives "SERDAT".

b) U703 control is performed by Q701 (Zone J-2) whose output is high (U703 on) whenever REML is "LOW" (REM pushbutton is depressed). When REM is not depressed, Q701 is controlled by U712C (Zone J-3). Input to U712C is RNG TIM (U702, pin 5) which is "HIGH" (thus Q701 is "HIGH", U703 is on) at all times except during LOAD RANGE, R1, R2, R4, and R8 periods of the INCLK pulse train. (See timing diagram 28247E). Thus the "SDAT" from the interface controls the timing (through TRIG mode, TRIGGER, and HOLD bits on "SDAT" and "SERDAT"), and the front panel controls range selection when REM is not depressed.

c) The right NOR gate (pins 3, 4, 5, 6) of U701 is controlled by RNG TIM (pin 3) and REML (pin 4). The range control data (R1, R2, R4, and R8) is on U701 pin 5. This data is generated by shift register U708 which is clocked by INCLK (Zone I-1) from U103. Resistors R738 (Zone J-3) and R737 (Zone J-5) adjust level.

d) The other NOR gate (pins 11, 12, 13, 4) of U701 selects the appropriate end range limits in U103 by setting SERDAT low during "ABR" time (See Timing Diagram 28247E). SDAT is uncommitted by the Model 1722 or 1723 during t_4 time, thus Q711 controls SERDAT even though U703 is on.

3. Phase Lock Loop.

a) U716 (Zone N2) is a phase lock loop circuit whose output (pin 4) operates at nominally 5.2kHz. U715 divides this frequency by 8 to 650 Hz at U715, pin 10. U716 "locks" this 650 Hz output (pin 3) to t_4B (pin 14) after level shifting by Q722 (Zone K-1) and Q721 (Zone L-1). t_4B occurs 208 times every 320ms conversion or every 1.53ms.

b) U714 and U713A divide the 5.2 kHz output by 5. U713 divides this output by 2 to generate 50% duty cycle, 520 Hz, complementary signals at SYNC 1 and SYNC 2. These signals are used to operate the chopper amplifier in the nanovolt preamp.

4. On-Board Supplies. Q719 (Zone K-3) and Q718 (Zone N-6) provide +11V and -10V supplies to various circuits on PC-421.

5-11. POWER SUPPLY (Schematic 27938D).

a. This schematic contains the battery switching, line voltage switching, line transformer and voltage regulators for the entire instrument. Three separate regulators are used. VR402 is a ±15 volt regulator (±3% accuracy) with typically 0.1% regulation and delivers ±15 volts to most of the circuitry on the Model 174. VR404 is a +8 volt regulator which is used as the positive supply to the LSI chip (U103 on schematic 27936F). VR401 is a +5 volt regulator which is used to drive the display, the digital logic circuitry in the A/D converter and most relays.

b. VR402 is a ±15 volt dual tracking regulator. It is an integrated circuit with complete regulated circuitry and reference elements built in. It is either driven by transformer T401, or from ±19.2 volt batteries in the Model 1728 Battery Pack. Connected to the transformer is a full wave rectifier composed of CR402 and 2 filter capacitors C401 and C402, which supplies about 30 volts to Q403 and Q401 and the battery charging circuitry.

c. If the Model 1728 Battery Pack is installed in the Model 174 the batteries will be charged through the unregulated voltages. When the instrument is line powered resistors R401, R402, and R408 feed the charge inputs on the battery pack. These resistors drop the charging current to a trickle charge level.

d. The preregulated V+ input to VR402 supplies the +8 volt regulator VR404. This input goes through dropping resistor R403 to further reduce the voltage down to an acceptable level for VR404. The input for VR401 (+5V regulator) is derived from transformer secondary (pins 7 and 8), full wave rectifier CR401 and preregulator Q402. This voltage also charges the 8.4 batteries.

e. In BAT mode the ±19.2 volt batteries and the +8.4 volt batteries connect to the input terminals of VR401 and VR402. The 8 volt regulator (VR404) is fed through the 270 ohm resistor (R403). The LINE Switch also supplies ac voltage from the transformer to the Model 1722 for its regulated 5 volt supply. Thus, when the Model 174 power is turned off, power is also removed from the Model 1722.

f. Transformer T401 has two internal shields. One secondary shield is tied to pin 10 and one primary shield is tied to power ground. This shielding provides line isolation. When switch S402 is at 117V position, the dual primary windings of T401 are connected in parallel and the Model 174 is set for nominal 117V operation.* When switch S402 is at 234V position, the primary windings are in series and the Model 174 is set for nominal 234 operation).*

*NOTE

Switch S401 has two positions: NORM and LO. If set to NORM, the line voltage range is 105-125 volts or 210-250 volts. If set to LO, the line voltage range is 90-110 or 195-235 volts.

SECTION 6. MAINTENANCE.

6-1. GENERAL. This section contains information necessary to maintain the instrument. Included are procedures for electrical Performance Verification, Adjustment/Calibration, Troubleshooting, and Fuse Replacement.

6-2. REQUIRED TEST EQUIPMENT. Recommended test equipment for Performance Verification is given in Table 6-1. Test equipment for Adjustment/Calibration is given in Table 6-2. Alternate test equipment may be substituted if specifications equal the stated characteristics.

TABLE 6-1.
Test Equipment For Performance Verification

ITEM	DESCRIPTION	SPECIFICATION	MFR.	MFR. MODEL
A	DC Calibrator	0.2V, 2V, 20V, 200V, 1000V ±0.002% or 20µV	Fluke	343A
B	AC Calibrator	0.2V, 2V, 20V, 200V ±0.022%	H-P	745A
C	AC Calibrator/Amplifier	1000V @ ±0.04%	H-P	745A/746A
D	Decade Resistor	2KΩ, 10KΩ, 20KΩ, 200KΩ 1MΩ, 2MΩ, 10MΩ, 20MΩ, ±0.01% 200MΩ, 0.1%	ESI	RS725
E	Current Source	200µA, 2mA, 20mA, ±0.006%	Fluke	333B
F	Current Source	200mA, 2A ±0.02%	Fluke	382A
G	1MΩ Resistor	≥1/8W, ±1% tolerance	K-I	R-88-1MΩ
H	100Ω Per Step 4-Terminal Low Thermal Resistor	±0.01% tolerance	ESI	SR1010

6-3. PERFORMANCE VERIFICATION. Use the following procedures to verify basic operation of the instrument. All measurements should be made at an ambient temperature within the range of 20°C to 30°C and relative humidity less than 70%. If the instrument is out of specification at any point, perform a complete calibration as given in paragraph 6-4. If the instrument is "IN WARRANTY", that is, it has been less than 6 months after date of shipment, contact your Keithley representative or the factory.

It is recommended that this verification be performed every 6 months. With the exception of the A/D and 1744 Ohmmeter Option, if the instrument does not indicate within the allowable limits, only that function need be recalibrated. The 3 and 30 mVdc ranges may be recalibrated independently from the A/D.

IMPORTANT

The Performance Verification should be performed by qualified personnel using accurate and reliable test equipment as given in Table 6-1. Care should be taken to avoid electrical shock when the calibration or other maintenance is performed with the line cord connected to ac power.

NOTE

This Procedure is intended to verify only the basic accuracy of the Model 174 in voltage, current, and resistance modes. Test equipment accuracy should be X10 better than the measurement accuracy. In many cases the equipment listed in Table 6-1 is not X10 better because such equipment is not commercially available. In these instances the Allowable Reading in terms of the "Absolute Accuracy" should be used. Recommended verification period is every 6 months.

a. Stabilization. Allow the Model 174 to stabilize with power on for a least one hour prior to performing the Performance Verification.

b. Input Resistance Check (DC Volts).

1. Select DC V function.
2. Select the 3 volt DC range.
3. Set the Calibrator (A) to the 10-Volt range.
4. Set the Calibrator output to 0 volts.
5. Record the Model 174 reading and identify as V00.
6. Set the Calibrator output to 2 volts.
7. Record the Model 174 reading and identify as V20.
8. Connect the 1 Megohm Resistor (G) between the Calibrator output high and the Model 174 input HI.
9. Repeat steps 3, 4, 5, and 6 except identify the readings as V01 and V21 respectively.
10. Calculate V20-V00, and identify as "A".
11. Calculate V21-V01, and identify as "B".
12. Verify that "A"-"B" does not exceed 20 digits. This will ensure that the input resistance is greater than 10^9 ohms.

c. Voltage Accuracy Check.

1. DC Voltage (300mV to 1000V Ranges).
   a) Select DC V and AUTORANGE.
   b) Connect the DC Calibrator (A) to the Model 174.
   c) Set the DC Calibrator to the output specified in Table 6-2.
   d) Verify that the Model 174 is within the limits specified under "Absolute Accuracy".
   e) Repeat steps c) and d) with negative voltage.

TABLE 6-2.
DC Voltage Performance Check (300 mV to 1000V)

Range	Voltage Applied	Allowable Reading 20°C-30°C	
		Relative Accuracy*	Absolute Accuracy**
300 mV	0.20000 Vdc	199.97 to 200.03	199.95 to 200.05
3 V	2.0000 Vdc	1.9997 to 2.0003	1.9996 to 2.0004
30 V	20.000 Vdc	19.997 to 20.003	19.996 to 20.004
300 V	200.00 Vdc	199.97 to 200.03	199.96 to 200.04
1000 V	1000.0 Vdc	999.8 to 1000.2	999.7 to 1000.3

*Does not include the uncertainty of the DC Calibrator.

**Does include the uncertainty of the DC Calibrator given in Table 6-1.

2. DC Voltage (30 mV Range).

a) Select DCV and 30 mV range.

b) Connect the DC Calibrator (A), 9KΩ Decade Resistor (D), and Low-Thermal Resistor (H) as shown in Figure 34.

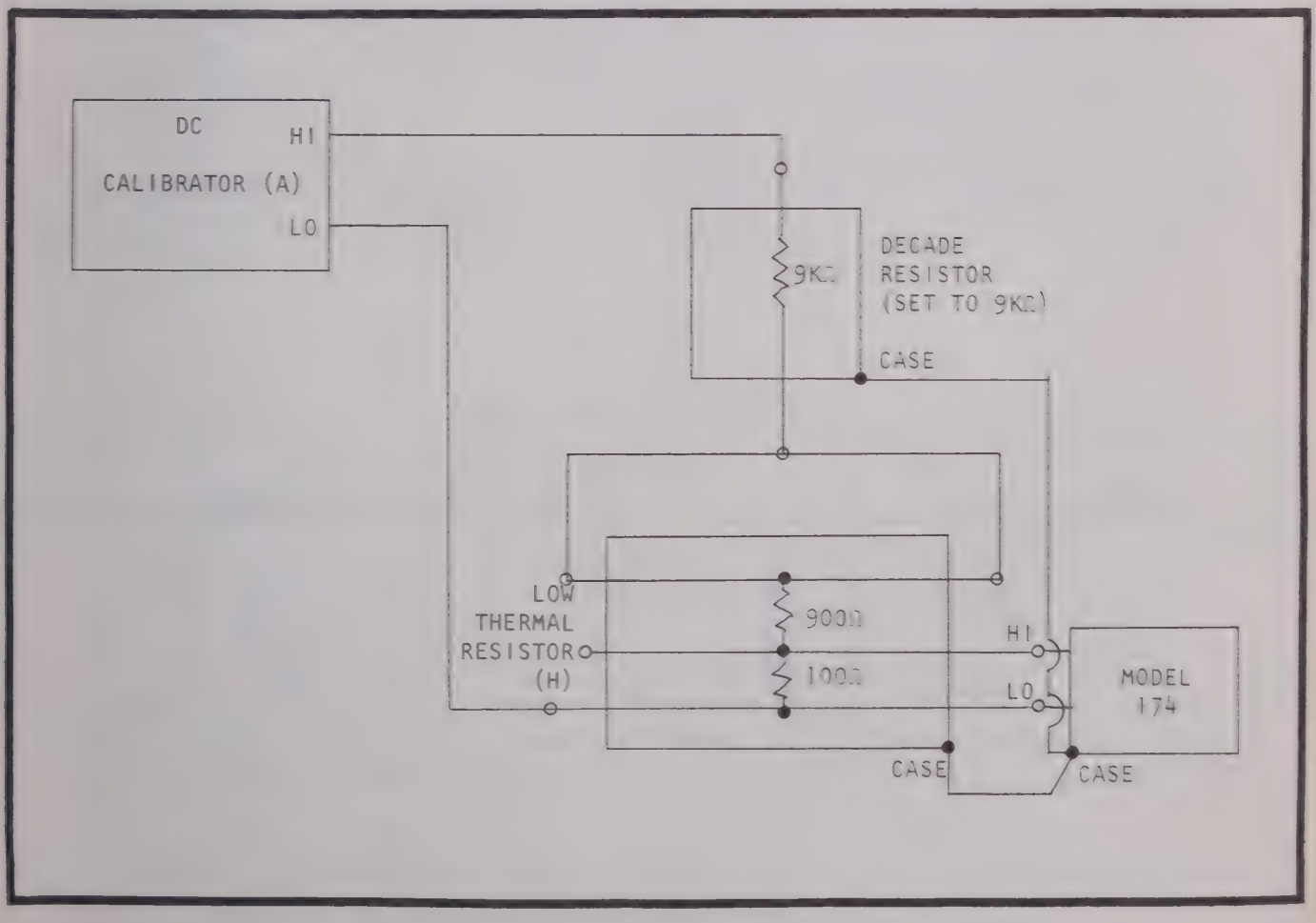


FIGURE 34. Test Circuit For 30 mV DC Accuracy Check.

c) Set the DC Calibrator to an output of 0.000000 V.

d) Adjust the Model 174 "mV ZERO" control for -0.0000 mV ±.0001 mV display.

e) Set the DC Calibrator to an output of +2.000000 V.

f) Verify that the Model 174 reading is between +19.991 and +20.009 mV dc.

IMPORTANT

Due to the design of the nanovolt amplifier within the Model 174, the 3 mV range will be in calibration when the 30 mV range is verified as above. Therefore, no specific verification procedure is given for the 3 mV range.

3. AC Voltage (Model 1740 AC Option).

a) Select AC V and AUTORANGE.

b) Connect the AC Calibrator (B) to the Model 174.

c) Set the AC Calibrator to the output specified in Table 6-3 (for applied voltages between 200 mV and 200V.)

d) Set the frequency to 50 Hz. Repeat verification at 20 kHz.

e) For the 1000 volt range connect the High Voltage Amplifier to the output of the AC Calibrator. (See the manufacturers instructions).

f) Set the AC Calibrator/High Voltage Amplifier combination (C) for an output of 1000 volts ac rms.

g) Verify the readings given in Table 6-3 (Absolute Accuracy) for frequencies of 50 Hz and 20 kHz.

TABLE 6-3.
AC Voltage Performance Check

Range	Voltage Applied	Allowable Reading 20°C - 30°C	
		Relative Accuracy*	Absolute Accuracy**
300 mV	200.00mV	199.54 to 200.46 mV	199.50 to 200.50 mV
3 V	2.0000 V	1.9954 to 2.0046 V	1.9950 to 2.0050 V
30 V	20.000 V	19954 to 20.046 V	19.950 to 20.050 V
300 V	200.00 V	199.54 to 200.46 V	199.42 to 200.58 V
1000 V	1000.0 V	997.4 to 1002.6 V	997.0 to 1003.0 V

*Does not include the uncertainty of the AC Calibrator.

**Does include the uncertainty of the AC Calibrator given in Table 6-1.

d. Resistance Accuracy Check. (Model 1744 Ohms Option).

1. HI Ohms.

a) Select HI OHMS and AUTORANGE.

b) Connect Decade Resistor (D) to the Model 174.

c) In order to compensate for lead resistance error, measure the resistance of the test leads, set the Decade Resistor dials to 0 and subtract the zero reading from the Model 174 display in the following tests.

d) Set the Decade Resistor to the resistance specified in Table 6-4.

e) Verify that the Model 174 is within the limits specified under "Absolute Accuracy".

TABLE 6-4.
Resistance performance Check (HI OHMS)

Range	Resistance Setting	Allowable Reading, 20°C - 30°C	
		Relative Accuracy*	Absolute Accuracy**
3 KΩ	2.0000 KΩ	1.9993 to 2.0007	1.9991 to 2.0009
30 KΩ	20.000 KΩ	19.993 to 20.007	19.991 to 20.009
300 KΩ	200.00 KΩ	199.93 to 200.07	199.91 to 200.09
3 MΩ	2.0000 MΩ	1.9989 to 2.0011	1.9987 to 2.0013
30 MΩ	20.000 MΩ	19.959 to 20.041	19.967 to 20.042
300 MΩ	200.00 MΩ	196.59 to 203.41	196.39 to 203.61

*Does not include the uncertainty of the Decade Resistor.

**Does include the uncertainty of the Decade Resistor given in Table 6-1.

2. LO Ohms.

a) Select LO OHMS and AUTORANGE.

b) Connect Decade Resistor (D) to the Model 174.

c) Measure the resistance of the test leads by setting the Decode Resistor dials to 0 and subtract this reading from the Model 174 display in the following tests.

d) Set the Decade Resistor to the resistance specified in Table 6-5.

e) Verify that the Model 174 is within the limits specified under "Absolute Accuracy".

TABLE 6-5.
Resistance Performance Check (LO OHMS)

Range	Resistance Setting	Allowable Reading, 20°C - 30°C	
		Relative Accuracy*	Absolute Accuracy**
300 Ω	200.00 Ω	199.92 to 200.08	199.90 to 200.10
3 KΩ	2.0000 KΩ	1.9993 to 2.0007	1.9991 to 2.0009
30 KΩ	20.000 KΩ	19.993 to 20.007	19.991 to 20.009
300 KΩ	200.00 KΩ	199.89 to 200.11	199.87 to 200.13
3 MΩ	2.0000 MΩ	19.959 to 20.041	1.9957 to 2.0043
30 MΩ	20.000 MΩ	19.799 to 20.201	19.797 to 20.203

* Does not include the uncertainty of the Decade Resistor.

**Does include the uncertainty of the Decade Resistor given in Table 6-1.

e. Current Accuracy Check (Model 1745 Current Option).

1. DC Current (300 µA to 3A Ranges).

a) Select DC A.

b) Connect Current Source (E) to the Model 174.

c) Set the Current Source to the current specified in Table 6-6.

d) Select the appropriate range on the Model 174.

e) Verify that the Model 174 is within the limits specified under "Absolute Accuracy".

f) Repeat steps c), d), and e) using a negative input.

TABLE 6-6.
DC Current Performance Check

Range	Current Applied	Allowable Reading, 20°C - 30°C Relative Accuracy*	Absolute Accuracy**
300 µA	200.00 µA	199.87 to 200.13	199.86 to 200.14
3 mA	2.0000 mA	1.9988 to 2.0012	1.9987 to 2.0013
30 mA	20.000 mA	19.988 to 20.012	19.987 to 20.013
300 mA	200.00 mA	199.86 to 200.14	198.82 to 201.18
3 A	1.0000 A	1.9982 to 2.0018	1.9978 to 2.0022

*Does not include the uncertainty of the Current Source.

** Does include the uncertainty of the Current Source.

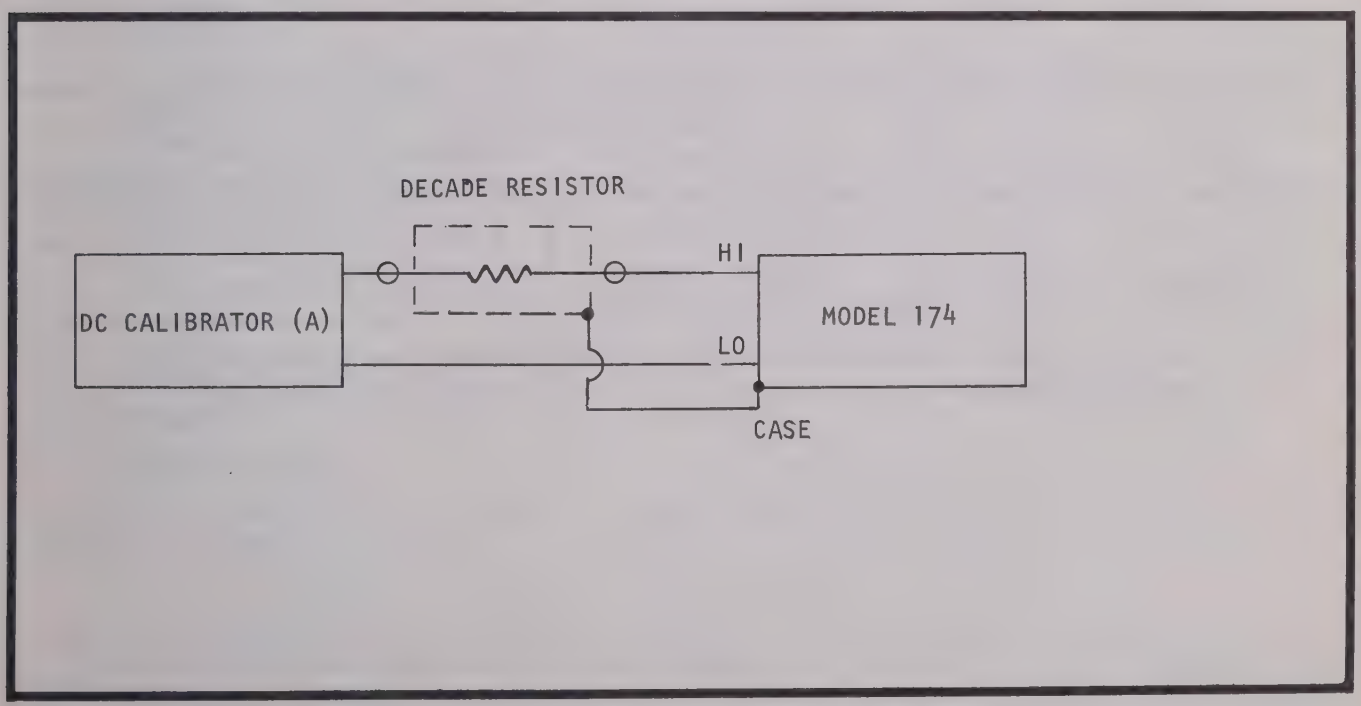


FIGURE 35. Test Circuit For 3µA Verification.

2. DC Current (3μA and 30μA Ranges)

a) Select DC A

b) Select 30μA range.

c) Connect the DC Calibrator (A) and series 1MΩ Decade Resistor (D) to the Model 174 input terminals, as shown in Figure 35.

d) Set the DC Calibrator to 20.200 volts dc.

e) Verify that the Model 174 is within the limits shown in Table 6-7 under "Absolute Accuracy".

NOTE

The DC Calibrator output is adjusted to compensate for voltage drop across the 1MΩ Decade Resistor. The input voltage across the Model 174 will be 0.2 Volts. The tolerances include the uncertainty of the Decade Resistor (D).

f) Repeat steps d) and e) using a negative input.

g) Select the 3 μA range.

h) Connect the DC Calibrator (A) and series 10MΩ Decade Resistor (D) to the Model 174 input terminals, as shown in Figure 35.

i) Set the DC Calibrator to 20.200 volts dc.

j) Verify that the Model 174 is within the limits shown in Table 6-7 under "Absolute Accuracy".

k) Repeat steps i) and j) using a negative input.

TABLE 6-7.
DC Current Performance Check (3μA and 30μA Ranges).

Range	Current Applied	Allowable Reading, 20°C - 30°C	
		Relative Accuracy*	Absolute Accuracy**
3μA	2μA	1.9978 to 2.0022	1.9976 to 2.0024
30μA	20μA	1.9988 to 2.0012	1.9986 to 2.0014

*Does not include the uncertainty of the Current Source.

**Does include the uncertainty of the Current Source.

6-4. ADJUSTMENT/CALIBRATION PROCEDURE. The following adjustments should be performed when a specification has been determined to be out of tolerance. For checking the instrument to the published specifications, the Performance Verification procedure (paragraph 6-3) should be used. The calibration procedure should be performed under laboratory conditions (25°C ± 1°C ambient and relative humidity less than 70%).

NOTE

1. If the Model 1744 Ohms Option is field-installed, the entire adjustment procedure must be performed to ensure that rated accuracy is achieved.
2. If the Model 1740 AC Option is field-installed, section 6-4e must be performed to ensure that rated accuracy is achieved. The other functions are not affected by the installation of the Model 1740.
3. If the Model 1745 Current Option is field-installed, section 6-4g must be performed to ensure that rated accuracy is achieved.

a. How to Install the Model 1743 Calibration Cover.

1. Disconnect the line cord from ac power outlet.

2. Depress the LINE pushbutton to discharge any voltages developed across capacitors in the power supply.

3. Remove the four Phillips screws on the top and lift off the top cover.

4. Temporarily disconnect and remove the Model 1728, 1722, or 1723 options (if installed at this time).

5. Check the Line Switches S401 and S402 for proper setting.

6. Connect the following calibration leads furnished with the Model 1743 Maintenance Kit.

a) Connect the single green wire to Test Lead TP702 (Power Supply Common) shown in Figure 36.

b) Connect the 2-wire test lead (red, black) to test points TP101/TP102 shown in Figure 36. The red lead is positioned on the left side of the instrument (TP101) as viewed from the front panel.

7. Before the Calibration Cover is fastened down, pass the free ends of the green, red and black wires through the holes in the Calibration Cover corresponding to TP702 and TP101/TP102 respectively.

8. Place the Calibration Cover in position and fasten down using the "Thumb Screws" furnished with the kit.

b. Power-Up and Stabilization.

1. Connect the line cord to ac power.

2. Depress LINE.

3. Allow the Model 174 to stabilize with the Model 1743 Calibration Cover in place for at least 1 hour.

NOTE

It is important that the calibration sequence be followed exactly in the order given, because the adjustments are interrelated and dependent on prior calibration steps.

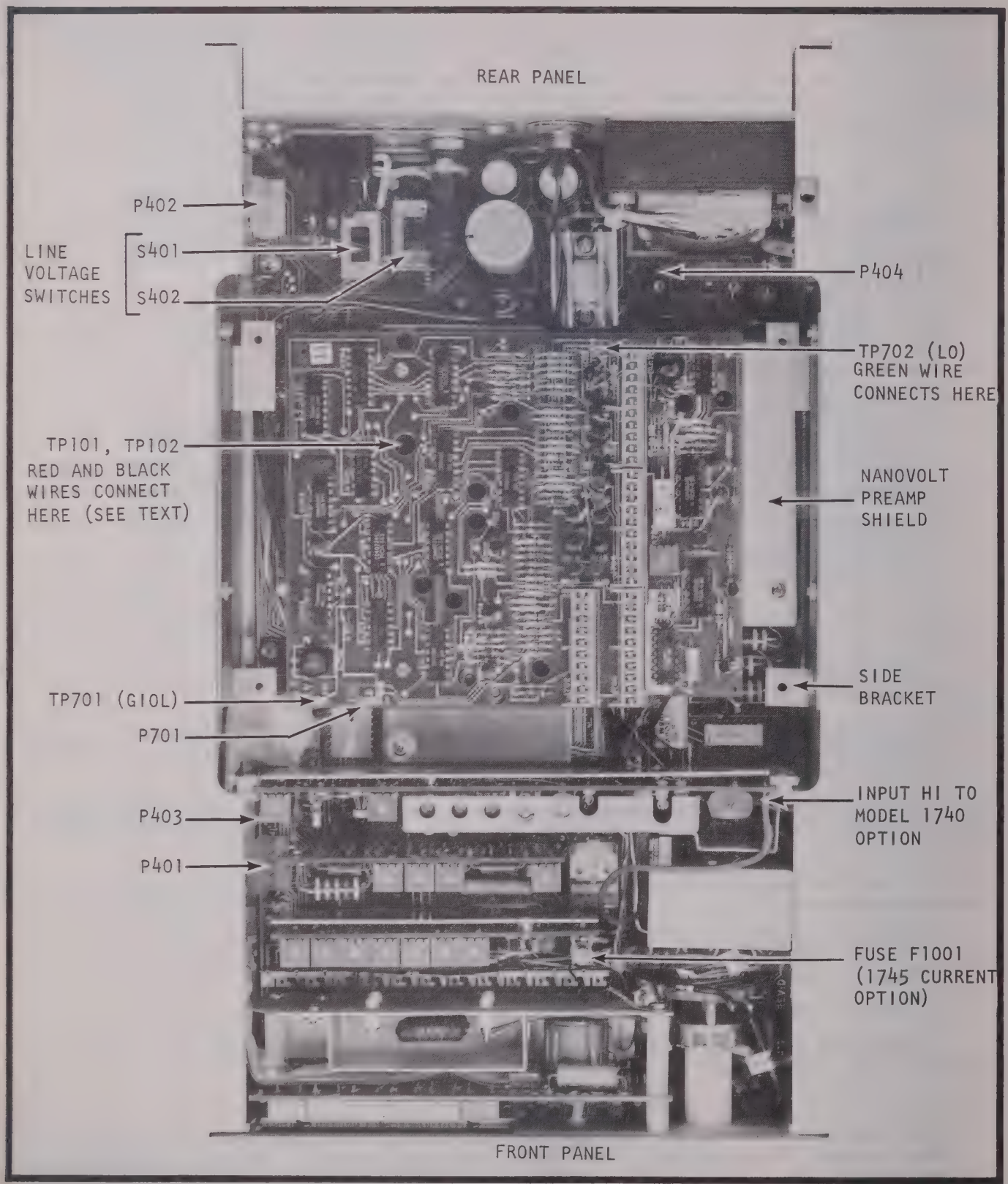


FIGURE 36. Model 174 Top View With Cover Removed.

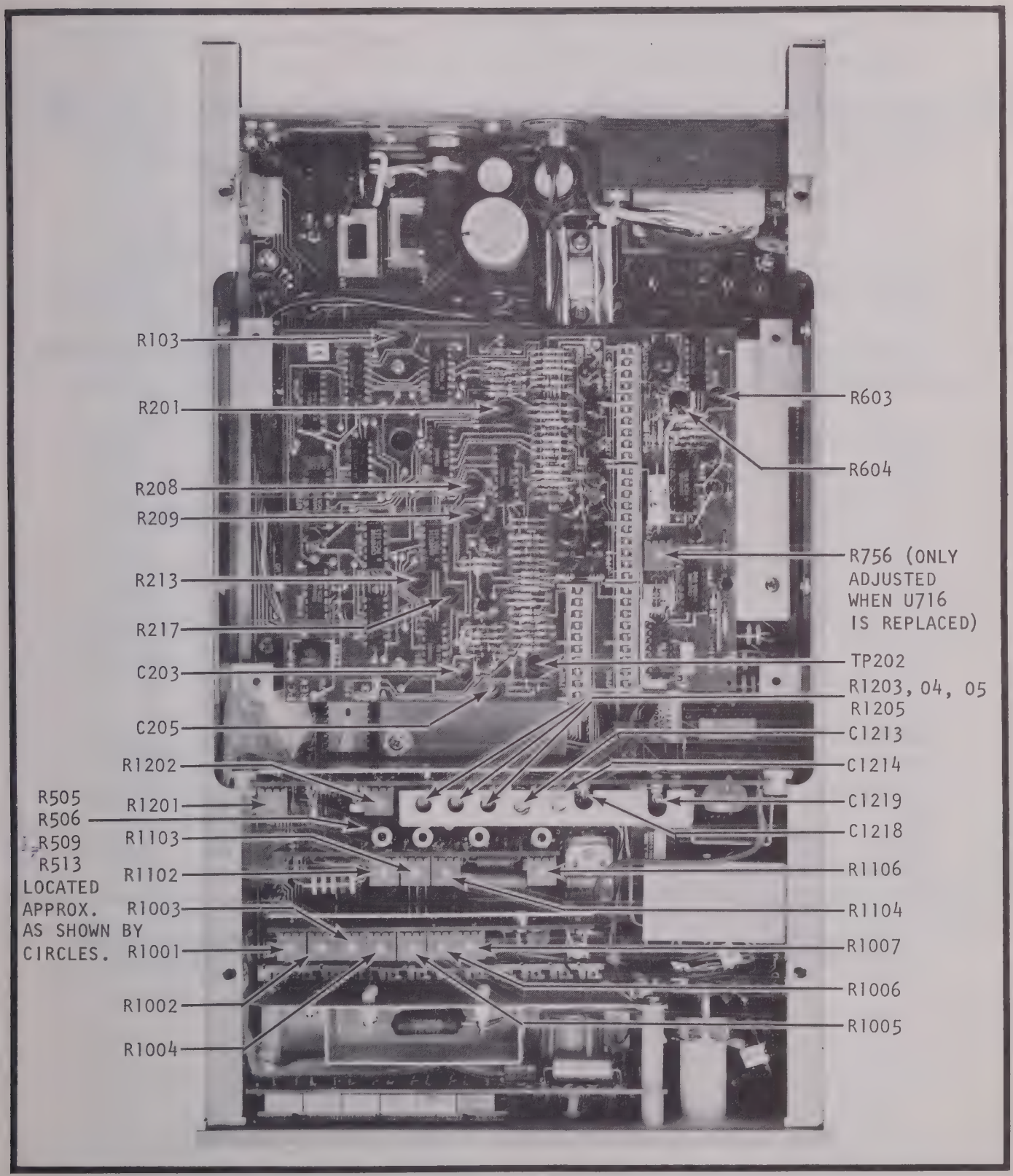


FIGURE 37. Model 174 Calibration Adjustments.

TABLE 6-8.
List of Test Equipment Required For Adjustment/Calibration

ITEM	DESCRIPTION	Minimum SPECIFICATION NEEDED	MFR	MFR MODEL
A	DC Calibrator	+0.290005V +2.90005V +29.0005V +290.005V +1000.05V +29.29V } All ±0.002%	Fluke	343A
B	AC Calibrator	10mV, 1V, 10V, 100V, ±0.022% @ 1kHz, 20kHz	H-P	745A
C	AC Calibrator/Amplifier	1000V ±0.04% @ 1kHz, 20kHz	H-P	745A/746A
D	Decade Resistor	2KΩ, 20KΩ, 200KΩ, 1MΩ, 2MΩ, 10MΩ, 20MΩ, ±0.01%	ESI	RS725
E	Current Source	290μA, 2.9mA, 10mA, ±0.006%	Fluke	333B
F	Current Source	200mA, 1A ±0.02%	Fluke	382A
G	Oscilloscope	5mV/Div., Dual Trace, With 10MΩProbe.	Tektronix	465
H	Microvoltmeter	10μV Full Scale, ±2%	K-J	155
I	DMM	1.00000 ±0.001%	K-J	5900
J	Test Circuit	Resistor, 2MΩ, 1%, 0.2W } Parallel Capacitor, 1μF, 50V } Combination	K-J K-J	R-253-2M C-215-1M
K	Maintenance Kit	Calibration Cover, Calibration Leads, Extender Cards and Cables.	K-J	1743
L	Low-Thermal Test Leads	Low-Thermal, Coaxial Input Leads	K-J	1747
M	Low-Thermal Short	(Furnished with the Model 174)	K-J	1746
N	100Ω Per Step 4-Terminal Low-Thermal Resistor	±0.01% Tolerance	ESI	SR1010

* NOTE: For the 30μA and 300μA ranges, a Current Source must be composed of the DC Calibrator (A) and series connected Decade Resistor (D), as in Figure 35.

c. A/D Calibration.

NOTE

This procedure must precede the analog section calibration to ensure that the Model 174 will meet all rated specifications.

1. Capture Range Adjustments.

a) Set to DC V function and 300mV range.

b) Connect the Model 1746 Low-Thermal Short to the input.

c) Make sure the 2 wire test lead (furnished with the Model 1743 Maintenance Kit) is connected at TP101 and TP102, as described in paragraph 6-4 a, 6, b).

d) Connect Oscilloscope (G) between the following points:

1) Oscilloscope External Trigger to "red" at TP101 (FON), using 10MΩ Probe.

2) Oscilloscope Vertical Input to "black" at TP102 (Prefilter), using 10MΩ Probe.

3) Oscilloscope GND to "green" ground at TP702 (LOW).

e) Set the Oscilloscope controls as follows:

1) Trigger: +, DC coupled

2) Vertical: DC, 0.5V/division (.05V/Division x 10 in Probe).

3) Time Base: 20 ms/division

f) For the following adjustment refer to the trace shown in Figure 38.

g) Adjust potentiometer R103 (Auto Cal ACAL) for a level of +1V ±0.2V during the Auto Cal time period.

h) Adjust potentiometer R201 (Auto Zero AZ1) for a level of +1V ±0.2V during the AZ1 period.

i) Adjust potentiometer R217 (Auto Zero AZ2) for a level of +1V ±0.2V during the AZ2 period.

j) Repeat steps h), i), and j) until all levels are within +1V ±0.2V simultaneously.

NOTE

The following steps k) 1) through k) 3) are required only if the Model 1744 Ohms Option is installed.

k) Set to LOΩ function and 3 kΩ range.

1) Adjust potentiometer R1106 (Ω BIAS) for a level of +1V ±0.2V during Auto Zero AZ1 and Auto Zero AZ2 periods.

2) Adjust potentiometer R208 (0.3V Ref) for a level of +1V ±0.2V during Auto Cal ACAL period.

3) Repeat steps 1) and 2) until both conditons are met simultaneously.

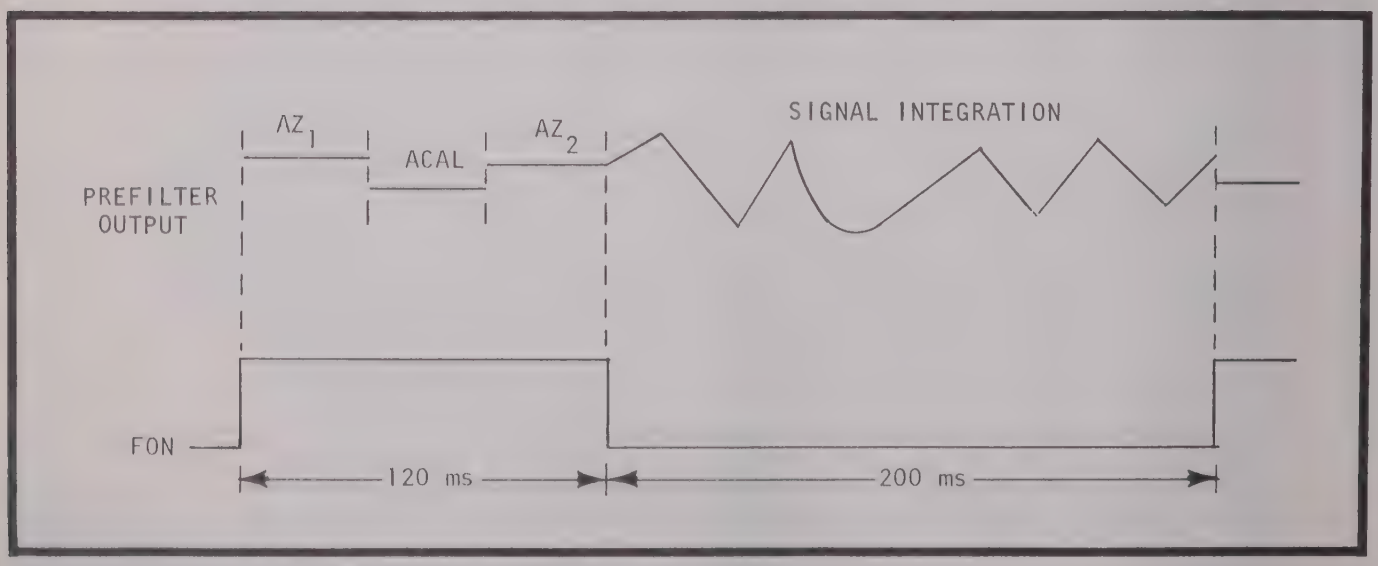


FIGURE 38. Waveform For A/D Calibration

2. Zero and Offset Current Adjustments (300mV range).

a) Set to V DC function and 300 mV range.

b) Connect the Model 1746 Low-Thermal Short to the input.

c) Record the Model 174 reading.

d) Remove the Model 1746.

e) Connect the Test Circuit (J) across input HI and LO.

f) Adjust variable capacitor C203 (Input Current) to achieve the same Model 174 reading as in step c) within ±2 digits.

g) Remove the Test Circuit.

NOTE

The following steps h) through j) are required only if the Model 1744 Ohms Option is installed.

h) Connect the Model 1746 Low-Thermal Short.

i) Set to LO Ω function and 3 KΩ range.

j) Adjust variable capacitor C205 (ohms Zero) for a zero reading on the Model 174.

k) Set to DC V function and 300 mV range.

l) Adjust potentiometer R509 (300 mV Zero) for a zero reading.

m) Verify that during the 200 ms Integration period the output at TP102 (Prefilter) has no more than 10 transitions from positive slope to negative slope (and vice-versa).

d. DC Voltage Calibration.

1. Zero and Offset Current Adjustments (3 mV and 30 mV ranges).

a) Set to DC V function and 30 mV range.

b) Connect the Model 1746 Low-Thermal Short.

c) Verify that the mV ZERO Control (R623) has a control range of 50µV ±12µV, passing through zero no less than 5 digits from either end position of the mV Zero Control.

NOTE

If the zero is less than 5 digits from the end position of the mV Zero Control, move jumper J603 to the next position in the direction which allows greater zeroing capability. Repeat test to verify the change.

d) Set to 3 mV range.

e) Connect the Model 1746 Low-Thermal Short.

f) Adjust the mV Zero Control for a zero reading ±2 digits.

g) Remove the Model 1746

h) Connect the 100 KΩ Resistor (D) across the input.

i) Adjust potentiometer R603 (Offset Current) for a zero reading ±2 digits.

j) Repeat steps e) through i) until both conditions are satisfied.

2. Gain Adjustment For 30 mV Range.

a) Set to DCV function and 3 mV range.

b) Connect the DC Calibrator (A) and (D) 9KΩ Decade Resistor and 100Ω Low-Thermal Resistor (M) as shown in Figure 34, on page 6-3.

c) Set the DC Calibrator for 0.000000 V dc.

d) Adjust the "mV ZERO" control for a display of -.0000mV.

e) Select 30mV Range.

f) Set the DC Calibrator for +2.90005 V dc.

g) Adjust potentiometer R604 (30 mV Gain) for a display of +29.000 mV to +29.001 mV.

d. DC Voltage Calibration.

3. Zero Adjustments.

a) Set to DCV function and 300 mV range.

b) Connect the DC Calibrator (A) to the Model 174 input.

c) Set the DC Calibrator for an output of +5μV (See NOTE below).

NOTE

It may be necessary to compensate for dc offset of the DC Calibrator. For example, if the dc calibrator offset is -2μV dc, then the DC Calibrator should be adjusted to +7μV to compensate for the offset. Monitor the voltage at the Model 174 input with microvoltmeter (H) to set the + 5μV input.

d) Adjust potentiometer R509 (300mV Zero) for a display which flashes between "-00.00" and "+00.01".

e) Set the Model 174 to 30 V range.

f) Set the DC Calibrator (A) for an output of +.0005V.

g) Adjust potentiometer R513 (30V Zero) for a display which flashes between "-0.000" and "+0.001".

4. Full Range Calibration.

   a) Connect the DC Calibrator to the input terminals.

   b) Set the instrument to the range given in Table 6-10.

   c) Set the DC Calibrator to the "Applied Input" level given in Table 6-10.

   d) Adjust the control given in Table 6-10 to achieve the display specified.

NOTE
Perform the calibration in the exact order given.

TABLE 6-10
Full Range DC Calibration

Range Setting	Applied Input	Control	Display Required**
3 V	+2.90005 V	2.9 V ADJ (R213)	+2.9000 to +2.9001 V
300 V	+290.005 V	290 V ADJ (R505)	+290.00 to +290.01 V
30 V	+29.0005 V	X10 GAIN (R209)	+29.000 to +29.001 V
1200 V	+1000.05 V	1 KV ADJ (R506)	+1000.0 to +1000.1 V

**Display should flash alternately between readings when the DC Calibrator is set to the applied input or to a setting of ±0.1 digit of applied input (e.g. 2.90004 to 2.90006 V).

e. AC Voltage Calibration. This procedure is required only if the Model 1740 AC Option is installed.

1. Set the Model 174 to AC V function and AUTORANGING.
2. Connect the AC Calibrator (B) to the input terminals.

NOTE

For voltages greater than 100 volts, use the AC Calibrator (B) along with the High Voltage Amplifier (C) as per manufacturers operating instructions.

3. Set the AC Calibrator to the voltage and frequency specified in Table 6-11.
4. Adjust the control given in the table to achieve the appropriate display.

NOTE

The steps must be performed in the exact order given in Table 6-11.

TABLE 6-11.
Full Range AC Calibration (Model 1740 Only)

Range Setting	Applied Input	Frequency	Control	Display Required
* 300 mV	10 mV	1kHz	R1202 (1kHz Adj)	009.99 to 010.01
* 3 V	1 V	1kHz	R1201 (1kHz Adj)	0.9999 to 1.0001
30 V	10 V	1kHz	R1205 (1kHz Adj)	09.999 to 10.001
300 V	100 V	1kHz	R1204 (1kHz Adj)	099.99 to 100.01
1000 V	1000 V	1kHz	R1203 (1kHz Adj)	0999.9 to 1000.1
1000 V	1000 V	20kHz	C1220, C1219 (20kHz Adj)	0999.9 to 1000.1
* 3 V	1 V	20kHz	C1218 (20kHz Adj)	0.9999 to 1.0001
30 V	10 V	20kHz	C1213 (20kHz Adj)	09.999 to 10.001
300 V	100 V	20kHz	C1214 (20kHz Adj)	99.99 to 100.01

* These adjustments are interactive. It may be necessary to perform the adjustments twice in order to achieve all conditions simultaneously.

f. Ohms Calibration. This procedure is required only if the Model 1744 Ohms Option is installed.

1. Connect Decade Resistor (D) to the Model 174. Set to 10MΩ.
2. Set the Model 174 to HIΩ function and AUTORANGE.
3. Adjust potentiometer R1104 (10 MΩ Adj) for a reading of 10.000 MΩ.
4. Set the Model 174 to LOΩ function.
5. Adjust potentiometer R1106 (Ω Bias) for 10.000 MΩ.
6. Repeat steps 2 through 5 until both readings are within ±1 digit simultaneously.
7. Verify that the test leads furnished with the Model 1743 Maintenance Kit are connected as in paragraph 6-4 a. page 6-9. (See also Figure 36.)
   a) Connect "green" between LOW and Oscilloscope low.
   b) Connect "black" between Pre-filter Output and Oscilloscope vertical input using 10 X Probe.
   c) Connect "red" between TP101 (FON) and Oscilloscope trigger.
8. Set the Oscilloscope controls as follows:

   Gain: .5v/div. (.05V/Div. X 10 in Probe).
   Time Base: 20 ms/div.
   Trigger: EXT.

9. Set the Model 174 to LO Ω function and AUTORANGE.
10. Connect the Model 1746 Low-Thermal Short.
11. Adjust potentiometer R208 (0.3V Ref) for +1V ±0.1V during the Auto Cal time period as shown in Figure 38, 6-14.
12. Verify that the Oscilloscope trace is +1V ±0.3V during the Auto Zero time period as shown in Figure 38, Page 6-14.
13. Check the calibration in steps 1 through 12 to ensure that conditions have not changed. Readjust potentiometers R1104, R1106, and R208 as necessary to achieve the desired conditions.
14. Set the Model 174 to HI Ω function and AUTORANGE.
15. Connect Decade Resistor (D) to the Model 174.
16. Set the Decade Resistor to 290.000K Ω.
17. Adjust potentiometer R1103 (290KΩ Adj) for a reading of 290.00 ±1 digit.
18. Set the Decade Resistor to 0Ω.
19. Record the residual resistance (R_0) as displayed on the Model 174.
20. Set the Decade Resistor to 2.900Ω + R_{01}.
21. Adjust potentiometer R1102 (2.9KΩ Adj) for a reading equal to 2.9000K + R_0 ±1 digit.

g. Current Calibration. This procedure is required only if the Model 1745 Ammeter Option is installed.

1. Set the Model 174 to DC A function.
2. Set the Model 174 to 3A range.
3. Connect Current Source (F) to the Model 174.
4. Set the Current Source (F) for +2A.
5. Adjust potentiometer R1007 for a reading of 2.000A ±1 digit.
6. Set the Model 174 to 300mA range.
7. Set the Current Source (F) for 290 mA.
8. Adjust potentiometer R1006 for a reading of 290.00 mA ±1 digit.
9. Set the Model 174 to 30mA range.
10. Set the Current Source (E) for 29mA.
11. Adjust potentiometer R1005 for a reading of 29.000 mA ±1 digit.
12. Set the Model 174 to 3 mA range.
13. Set the Current Source (E) for 2.9000 mA.
14. Adjust potentiometer R1004 for a reading of 2.9000 mA ±1 digit.
15. Set the Model 174 to 300µA range.
16. Set the Current Source (E) for 290.00µA.
17. Adjust potentiometer R1003 for a reading of 290.00µA ±1 digit.
18. Set the Model 174 to 30µA range.
19. Connect DC Calibrator (A) and 1MΩ Decade Resistor (D) to form a current source and connect to the Model 174, as in Figure 35 on page 6-7.
20. Set the DC Calibrator (A) to 29.29V.
21. Adjust potentiometer R1002 for a reading of 29.000µA ±1 digit.
22. Set the Model 174 to 3µA range.
23. Change the Decade Resistor (D) to 10MΩ.
24. Check that the DC Calibrator setting is 29.29V.
25. Adjust potentiometer R1001 for a reading of 2.9000µA ±5 digits.

END OF CALIBRATION/ADJUSTMENT PROCEDURE.

6-5. TROUBLESHOOTING.

a. Chassis Dis-assembly. If there is a need to partially dis-assemble the Model 174 chassis to replace a part, the following procedure should be followed.

1. Remove the line cord from ac power.
2. Set the Model 174 to LINE power to discharge voltages in the power supply.
3. Remove the top cover (Item 12) by unscrewing the 4 Phillips screws as shown in Figure 2.
4. The Side Dress Panels (Item 11) are held in place by a Corner Bracket (Item 7).
5. To remove a Side Dress Panel, slightly loosen the Phillips screws (Item 8) in 2 places.
6. Slide the Side Dress Panels toward the rear and remove.

NOTE

At this point the chassis is ready for further dis-assembly as necessary.

b. How to Gain Access to the Nanovolt Preamp Circuit. The Model 174 contains a shield which covers the Nanovolt Preamp section of the Mother Board PC-412. See Figure 36.

1. Remove the Side Dress Panel on the right side (as viewed from the front panel) as described above.
2. Remove two #6-32 x 5/16 Phillips screws which hold the small side bracket. The bracket is used to support either the Model 1722 or 1723 interface or the Model 1728 Battery Pack.
3. Remove two #6-32 Phillips screws which hold down the Nanovolt Preamp Shield (Item 21).

c. How to Replace the Model 1745 Current Fuse.

1. Remove the top cover by unscrewing the 4 Phillips screws as shown in Figure 2.
2. Remove 1745 Ammeter Option.
3. Locate Fuse F1001 on the Model 1745 Ammeter Option.
4. Replace fuse with a Keithley Part No. Fu-39. The fuse rating is 4 amperes.
5. Install 1745 Ammeter Option, as in Figure 4.
6. Replace Top Cover.

d. Troubleshooting Hints. Table 6-12 describes the Symptoms and Probable Faulty Component for a variety of possible malfunctions. It is beyond the scope of this Instruction Manual to list all possible symptoms. Therefore, the Keithley represenative in your area should be contacted in the event repair is needed. For In-Warranty repairs within the continental U.S.A. contact the factory for shipping instructions.

TABLE 6-12
Troubleshooting Hints

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
a) No display (LINE mode)	1) Line switch set incorrectly.	Check connection to line power. Check LINE switch setting to conform to line voltage available.
	2) Fuse F401 is missing or open.	Check fuse. Replace with proper rating.
b) No display. (BAT mode)	4) Batteries need recharging. (Check for LO BAT indication.)	Connect instrument to line power.
	2) Battery fuses blown.	Check F401, F402, and F403.
	3) Batteries improperly installed on battery pack.	Check battery pack for proper polarity on all batteries.
	4. Battery cables improperly installed.	Check battery connections at P401 and R404. as in Figure 9.
c) No display (All modes)	1) Display cable P801 not properly connected.	Check plug P801 and mating connector J601. Make certain all pins are making proper contact (pins should not be bent). Check for proper orientation of the connector
	2) LSI module improperly installed.	Check U103 for proper installation. Make certain all pins are making contact (pins should not be bent).
	3) Power supply malfunction.	Check power supply voltages as described in Section 5-11.
d) Display is blank. or some segment on.	1) Clock waveform is missing.	Check pin 4 of LSI (U103) for a clock waveform of approx. 334 kHz, swinging between +4V and ØV. If waveform is present LSI U103 is probably faulty. If waveform is not present, integrated circuits U003, U004, transistor Q003, or ceramic resonator CR003 may be faulty.

TABLE 6-12 (Con't)
Troubleshooting Hints

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
e) One display bar missing on all digits.	1) Faulty connection between P801 and J601. 2) Cathode driver circuitry faulty. See schematic 27404D	Check plug P801 and mating connector J201. Make certain all pins are making contact. "a" bar: Check R802 pin 14 for signal. When "ON", voltage should be approx. +1.8V. "b" bar: Check R802 pin 16 "c" bar: Check R802 pin 15 "d" bar: Check R802 pin 9 'e" bar: Check R802 pin 12 "f" bar: Check R802 pin 10 "g" bar: Check R802 pin 13 decimal point: Check R802 pin 11
f) One digit missing.	1) Faulty connection between R301 and J201. 2) Anode driver circuitry faulty. See schematic 27939D.	Check plug P301 and mating connector J601. If units digit missing, check collector of Q810 for signal. When "ON", voltage should be approx. 4.8V. If tens digit missing, check collector of Q811. If hundreds digit missing, check collector Q812. If thousands digit, minus sign and function indicator missing, check collector Q813.
g) 10,000 digit missing. (except if reading is less than 10,000 counts)	Q301	On 10,000 digit, check collector Q301. If no signals are present problem could be transistor or integrated circuit U301.
h) Function indicator off.	Transistor Q815	
i) Faulty reading on Current function.	Current fuse F1001 is blown.	Replace fuse on Model 1745
j) Overload indication on 3mV DC range and/or 30mV DC range within input shorted.	1) K503 not closing	Check relay drive, relay contact resistance. Replace relay drive circuit or relay K503.
	2) Modulator drive	Check signal at Sync. 1 and Sync. 2. If bad timing, check phase lock loop and drive circuit on PC-421. If improper levels, replace Q604.
k) Out of spec offset current on 3mV DC or 30mV DC ranges.	1) Out of calibration	Recalibrate as per MAINTENANCE Section 6-4 d.1.

TABLE 6-13
Mechanical Parts List

Item No.	Description	Qty Per Assembly	Keithley Part No.
-	Chassis Assembly	-	-
-	Front Panel Assembly	-	-
1	Front Panel	1	27494C
2	Screw, Slotted, 6-32 x 3/8	4	-
3	Front Panel Overlay	1	27497B
4	Rear Panel	1	27814B
5	Side Extrusion Left	1	24874C
6	Side Extrusion Right	1	27807B
...	Bracket, left side (not shown)	1	27819A
...	Bracket, right side (not shown)	1	27821A
7	Corner Bracket	2	24745B
8	Screw, Socket 6-32 x 1/2	4	-
9	Screw, Phillips, 6-32 x 3/8	4	-
10	Clip for Side Dress	2	FA-101
11	Side Dress Panel	2	24360B
-	Top Cover Assembly	-	27845B
12	Top Cover	1	25771C
13	Screw, Socket, 6-32 x 5/16	4	-
-	Bottom Cover Assembly	-	27847B
14	Bottom Cover	1	25563C
15	Screw, Socket, 6-32 x 5/16	4	-
-	Feet Assembly	-	-
16	Feet	4	24322B
17	Rubber Tip	4	FE-6
18	Tilt Bail	1	24879B
19	Screw, Phillips, 6-32	4	-
20	Kep Nut, 6-32	4	-

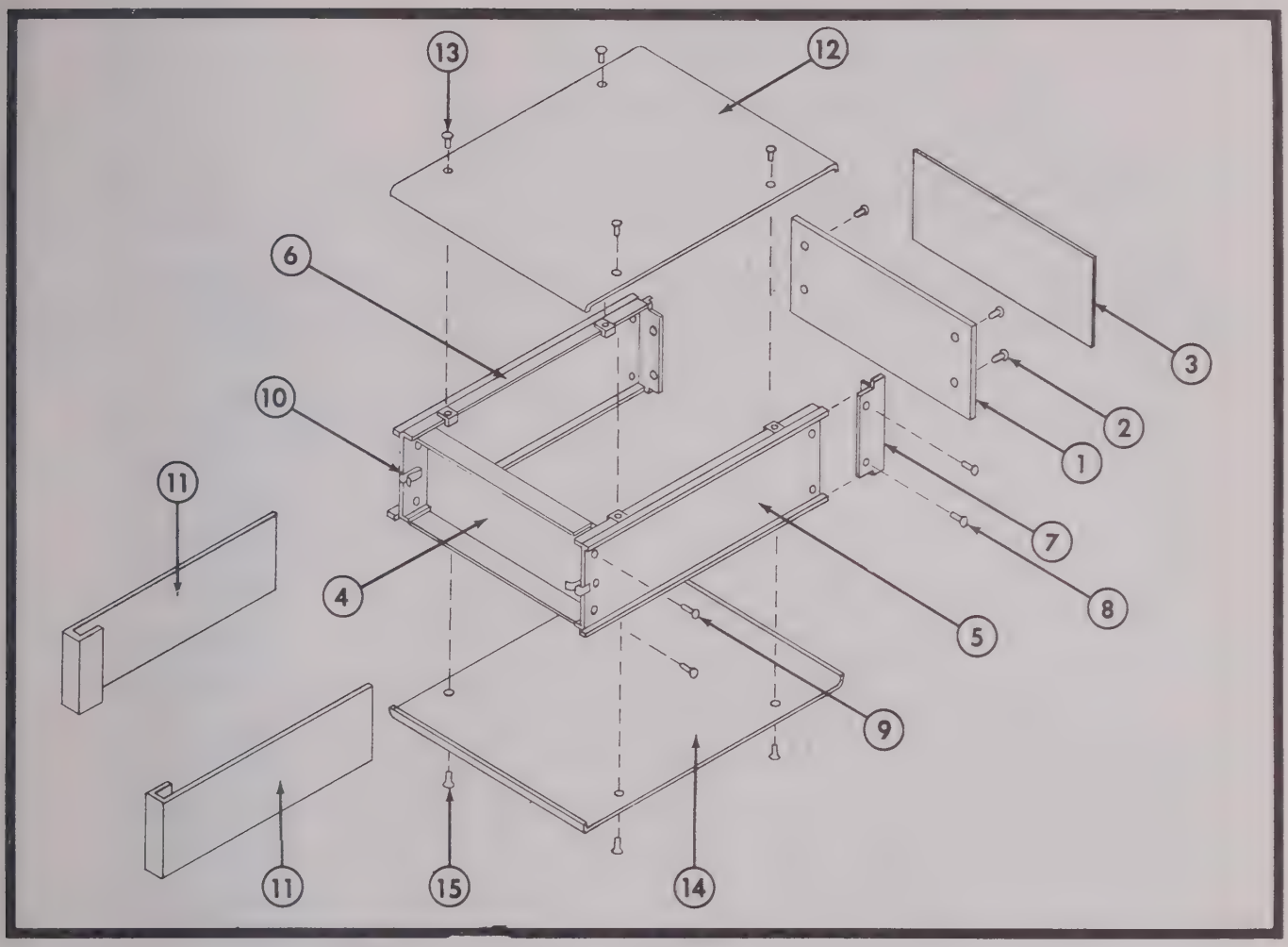


FIGURE 39. Chassis Assembly - Exploded View.

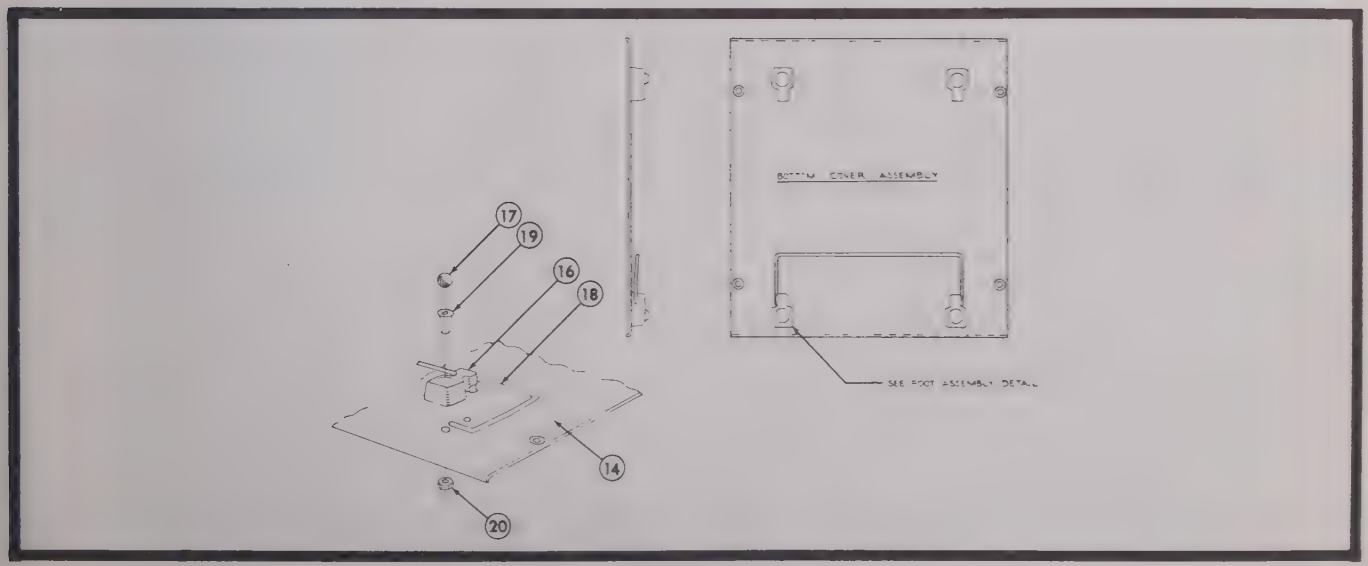


FIGURE 40. Bottom Cover Assembly.

SECTION 7. REPLACEABLE PARTS.

7-1. GENERAL. This section contains information for ordering replacement parts. The parts list is arranged in alphabetical order of their Circuit Designations.

7-2. ORDERING INFORMATION. To place an order or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover of the catalog for addresses. When ordering, include the following information.

a. Instrument Model Number.

b. Instrument Serial Number.

c. Part Description.

d. Circuit Designation (if applicable).

e. Keithley Part Number.

7-3. SCHEMATICS.

a. Switching, PC-412: Schematic No. 27935E. (Page 7-51)

b. Digital Board, PC-421: Schematic No. 28209E. (Page 7-56)

c. A/D Converter, PC-412: Schematic No. 27936F. (Page 7-52)

d. Nanovolt Pre-Amp, PC-412: Schematic No. 27937D. (Page 7-55)

e. Power Supply, PC-412: Schematic No. 27938D. (Page 7-55)

f. Display Board, PC-410: Schematic No. 27939D. (Page 7-58)

g. Model 1745 Current Option, PC-409: Schematic No. 27940C. (Page 7-61)

h. Model 1744 Ohms Option, PC-408: Schematic No. 27941C. (Page 7-60)

i. Model 1740 AC Option, PC-414: Schematic No. 27944D. (Page 7-59)

j. Model 1728 Rechargeable Battery Pack: Schematic No. 26758C. (Page 7-62)

k. Model 1722 Digital Interface: Schematic No. 27902E. (Page 7-66)

l. Model 1722 Digital Interface: Schematic No. 28019E. (Page 7-64)

m. Timing Diagrams for Model 1722. Schematic No's 28247E, 28248E, 28249D. (Pages 7-68, 7-69)

TABLE 7-1
Cross-Reference of Manufacturers

MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE
A-B	Allen-Bradley Corp. Milwaukee, WI 53204	01121
A-D	Analog Devices Inc. Cambridge, MA 02142	24355
AMP	Amp Inc. Harrisburg, PA 17105	00779
APH	Amphenol Broadview, IL 60153	02660
APX	Amperex Elkgrove Vlg, IL 60007	73445
BEC	Beckman Inst. Inc. Fullerton, CA 92634	73138
BLD	Belden Mfg. Co. Chicago, IL 60644	70903
BRG	Berg Electronics Inc. New Cumberland, PA 17070	22526
BRN	Bourns, Inc. Riverside, CA 92507	80294
BUS	Bussman Mfg. Div. St. Louis, MO 63017	71400
C-I	Components, Inc. Biddeford, ME 04005	06751
C-W	Continental-Wirt Elec. Corp. Warminster, PA 18974	79727
CAD	Caddock Riverside, CA 92507	19647
CAN	ITT Cannon Electric Santa Ana, CA 92702	
CLB	Centralab Division Milwaukee, WI 53201	71590
CLR	Clarostat Mfg. Co., Inc. Dover, NH 03820	12697
CTS	CTS Corporation Elkhart, IN 46514	71450
DIC	Dickson Electronics Corp. Scottsdale, AZ 85252	12954
DTN	Dielettron (Consolidated) New York City, NY 10013	
ECI	Electro Cube Inc. San Gabriel, CA 91776	14752
EDI	Electronic Devices Inc. Yonkers, NY 10710	
EFJ	E F Johnson Co. Waseca, MN 56093	74970
ERI	Erie Technological Prod. Erie, PA 16512	72982
F-I	Fairchild Inst Corp. Mountain View, CA 94043	07263
FUS	Bussman Mfg. (Fusetron) St. Louis, MO 63107	71400
G-E	General Electric Company Syracuse, NY 13201	03508
G-I	General Instrument Corp. Newark, NJ 07104	72699
GLD	Gould, Inc. St. Paul, MN 55165	52431
H-P	Hewlett-Packard Palo Alto, CA 94304	50434
DLE	Dale Electronics Inc. Columbus, NE 68601	91637

TABLE 7-1 (Cont'd)

MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE
INT	Intersil Inc. Cupertino, CA 95014	32293
IRC	IRC Division Burlington, IA 52601	07716
K-I	Keithley Instruments, Inc. Cleveland, Ohio 44139	80164
L-F	Littlefuse, Inc. Des Plaines, IL 60016	75915
MOL	Molex Downers Grove, IL 60515	27264
MOT	Motorola Semi Prod. Inc. Phoenix, AZ 85008	04713
NAT	National Semi Corp. Santa Clara, CA 95051	27014
P&B	Potter & Brumfield Princeton, IN 47670	
PAK	Paktron Vienna, VA 22180	
POM	Pomona Electric Pomona, CA 91766	05276
QTN	Q-Tron Santa Ana, CA 92705	
RAY	Raytheon Company Quincy, MA	94144
RCA	RCA Corporation Moorestown, NJ 08050	02734
RCL	RCL Electronics, Inc. Manchester, NH 03102	01686
SIE	Siemens Corporation Iselin, NJ 08830	25088
SIG	Signetics Corp. Sunnyvale, CA 94086	18324
SIL	Siliconix Inc. Santa Clara, CA 95054	17856
SPG	Sprague Electric Co. Visalia, CA 93278	14659
T-I	Texas Instruments, Inc. Dallas, TX 75231	01295
TEP	Tepro Electric Corp. Rochester, NY 14606	02985
TPL	Temple Tecate, CA 92080	29505
TRW	TRW Capacitor Div. Ogallala, NB 69153	84411
VIS	Vishay Resistor Products Malvern, PA 19355	18612
VRN	Vernitron Laconia, NH 03246	13150
WAB	Wabash-Magnetics Wabash, IN 46992	01101

MODEL 174 MAINFRAME, LESS OPTIONS AND ACCESSORIES

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
C001	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C002	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C003	0.1µF, 16V, CerD	.CLB	UL16-104	C-238-0.1M
C004	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C005	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C006	33pF, 1000V, CerD.	.CLB	DD330	C-64-33P
C007	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C008	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C009	2.2µF, 20V, ETT.	.C-I	TD1-20-225-20	C-179-2.2M
C010	0.47µF, 50V, Cer Film.	.ERI	8131050651474M	C-237-0.47M
C011	0.1µF, 50V, Cer Film	.E-M	5020ES50RD104M	C-237-0.1M
	"100" SERIES (Schematic 27936F) (PC-412)			
C101	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C102	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C103	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C104	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C105	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C106	0.022µF, 50V, MPC.	.ECI	625B1A224-J	C-201-0.022M
C107	0.0022µF, 200V, MPC.	.ECI	625B1C-473	C-221-0.0022M
C108	0.01µF, 100V, 10%, CAP	.PAK	PT-420	C-38-0.01M
C109	33µF, 1000V, CerD.	.CLB	DD-330	C-64-33P
C110	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C111	0.1µF, 16V, CerD	.CLB	UK16-104	C-238-0.1M
C112	0.22µF, 50V, MPC	.ECI	625B1A224-J	C-201-0.22M
C113	0.22µF, 50V, MPC	.ECI	625B1A224-J	C-201-0.22M
C114	0.22µF, 50V, MPC	.ECI	625B1A224-J	C-201-0.22M
C115	8.2pf, Capacitor, 50V, Cer	.CLB	C40C8R2K	C-282-8.2P
	"200" SERIES (Schematic 27936F) (PC-412)			
C201	15pF, 1000V, CerD.	.CLB	DD-150	C-64-15P
C202	2.2µF, 20V, ETT.	.C-I	TD1-20-225-20	C-179-2.2M
C203	.8-11pF, 1000V, HI-K, Glass.	.SPG	GHC11000	C-202-.8-11P
C204	3.3pF, 50V, Cer.	.CLB	C40C3R3D	C-282-3.3P
C205	.8-11pF, 1000V, HI-K, Glass.	.SPG	GHC11000	C-202-.8-11P
C206	0.0022µF, 200V, MPC.	.E-C	625B1C222	C-221-0.0022M
C207	100pF, 1000V, CerD	.CLB	DD-101	C-64-100P
C208	100pF, 1000V, CerD	.CLB	DD-101	C-64-100P
C209	100pF, 1000V, CerD	.CLB	DD-101	C-64-100P
C210	1500pF, 1000V, CerD.	.CLB	DD-152	C-64-1500P
C211	1.0µF, 50V, Cer Film	.E-M	5030ES50RD105M	C-237-1.0M
C212	1.0µF, 50V, Cer Film	.E-M	5030ES50RD105M	C-237-1.0M
C213	3.3pF, 50V, Cer Film	.CLB	C40C3R3D	C-282-3.3P

CAPACITORS (C) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 27938D) (PC-412)			
C401	470µF, 50V, +100 to -10%, CAP. . .	I-C	PD470M50	C-276-470M
C402	470µF, 50V, +100 to-100%, CAP. . .	I-C	PD470M50	C-276-470M
C403	0.1µF, 25V, +80 to -20%.	CLB	UK20-104	C-275-.1M
C404	2000µF, 25V, EAL.	K-I	...	C-255-2000M
C405	0.1µF, 25V, +80 to -20%.	CLB	UK20-104	C-275-.1M
C406	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
C407	0.33µF, 50V, Cer F	ERI	8131050651334M	C-237-.33M
C408	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
C409	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
C410	0.33µF, 50V, CerF.	ERI	8131050651334M	C-237-.33M
C411	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
	"500" SERIES (Schematic 27935E) (PC-412)			
C501	.01µF, 16V, CerD	CLB	UK16-103	C-238-.01M
C502	1000pF, 1000V, CerD.	ERI	808-000-Z5R0-102K	C-64-1000P
C503	.01µF, 16V, CerD	CLB	UK16-103	C-238-.01M
	"600" SERIES (Schematic 27937D) (PC-412)			
C601	100pF, 630V, Poly.	SIE	B31360-A1101-H	C-252-100p
C602	100pF, 630V, Poly.	SIE	B31360-A1101-H	C-252-100p
C603	33pF, 1000V, CerD.	CLB	DD330	C-64-33P
C604	4.0µF, 50V, MPC.	ECI	625B1A205	C-215-4
C605	.1µF, 250V, MtF.	AMP	C280AE/P100K	C-178-.1
C606	1.0µF, 50V, MPC.	ECI	625B1A105	C-215-1
C607	33pF, 1000V, CerD.	CLB	DD330	C-64-33P
C608	.01µF, 50V, MPC.	ECI	625B1A103-J	C-201-.01
C609	.01µF, 250V, MtF	AMP	C280AE/P10K	C-178-.01
C610	2.0µF, 50V, MPC.	ECI	625B1A205	C-215-2
C611	1.0µF, 200V, MPC	ECI	625B1C-105	C-221-1
	"700" SERIES (Schematic 28209E) (PC-421)			
C701	0.01µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C702	0.01µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C703	100µF, 15V, ETT.	NCI	KNS107E015K	C-228-100M
C704	0.01µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C705	2.2µF, 20V, ETT.	NCI	KNS225A020K	C-179-2.2M
C706	100µF, 15V, ETT.	C-I	TD501510710	C-228-100M
C707	1.2µF, 20V, ETT.	NCI	KNS125A020K	C-179-1.2M
C708	1µF, 100V, 10%, CAP.	ECI	230B1B05K	C-245-1M
C709	1.2µF, 20V, ETT.	NCI	KNS125A020K	C-179-1.2M
C710	0.1µ F, 50V, MPC	ECI	625B1A103-J	C-201-.01M

CAPACITORS (C) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"800" SERIES (Schematic 27939D) (PC-410)			
C801	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C802	330µF, 6V, 20%	.NCI	ENS337D006MI	C-270-330M
	"900" SERIES (Schematic 27935E) (PC-412)			
C901	33pF, 1000V, CerD.	.CLB	DD-330	C-64-33P
C902	0.15µF, 10%, 200VDC.	.TRW	1-200-10-X363UW	C-269-0.15M
C903	0.15µF, 10%, 200VDC.	.TRW	1-200-10-X363UW	C-269-0.15M
C904	0.15µF, 10%, 200VDC.	.TRW	1-200-10-X363UW	C-269-0.1M

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
CR001	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR002	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR003	Resonator, Ceramic, 669kHz	.VRN	TF-01-669	CR-7
	"100" SERIES (Schematic 27936F) (PC-412)			
CR101	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR102	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
	"200" SERIES (Schematic 27936F) (PC-412)			
CR201	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR202	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR203	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR204	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR205	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR206	DIP.	.INT	ID101	DN-3
CR207	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR208	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR209	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR210	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR211	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR212	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR213	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR214	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR215	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR216	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR217	DIP.	.INT	ID101	DN-3
CR218	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR219	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28
CR220	Rectifier, 75mA, 75V	.T-I	1N4148	RF-28

DIODES (CR) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 27938D) (PC-412)			
CR401	Four-Diode, Bridge, 100V, 2A . . .EDI		PD10	RF-36
CR402	Four-Diode, Bridge, 100V, 2A . . .EDI		PD10	RF-36
	"500" SERIES (Schematic 27935E) (PC-412)			
CR501	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	
CR502	NOT USED			
CR503	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR504	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
	"600" SERIES (Schematic 27937D) (PC-412)			
CR601	Rectifier, 1A, 800V. . . . . .INT		1N4006	RF-38
CR602	Rectifier, 1A, 800V. . . . . .INT		1N4006	RF-38
	"700" SERIES (Schematic 28209E) (PC-421)			
CR701	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR702	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR703	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR704	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR705	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR706	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR707	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR708	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR709	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR710	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR711	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR712	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR713	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
CR714	Rectifier, 75mA, 75V . . . . . .T-I		1N4148	RF-28
	"800" SERIES (Schematic 27939D) (PC-410)			
CR801	Rectifier, 1A, 800V. . . . . .MOT		1N4006	RF-38

DISPLAYS (DS)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"800" SERIES (Schematic 27939D) (PC-410)			
DS801	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS802	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS803	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS804	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS805	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS806	Digital Display, 7-Segment . . .	H-P	5082-7650	DD-13
DS807	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS808	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS809	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS810	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS811	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS812	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS813	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS814	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)
DS815	Pilot Lamp Assembly, LED, Red .	K-I	...	27837A (PL-63)

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 27936F) (PC-412)			
J201	16 Pin, DIP	K-I	-	SO-65
	"300" SERIES (Schematic 27935E) (PC-412)			
J301	NOT USED	---		---
J302	Input HI Terminal, Red.	POM	2854-2	BJ-9-2
J303	Input LO Terminal, Black.	POM	2854-0	BJ-9-0
J304	CASE Terminal, Green.	POM	2854-5	BJ-9-5
	"600" SERIES (Schematic 27937D) (PC-412)			
J601	3-Pin, Mini-PV.	BRG	65039-034	CS-270
J602	Mini-PV	BRG	47439	CS-236
J603	Mini-PV	BRG	47439	CS-236
	"700" SERIES (Schematic 28209E) (PC-421)			
J701	NOT USED	---	---	---
J702	Card-edge Connector	MOL	09-52-3102	CS-332-10
J703	Card-edge Connector	MOL	09-52-3102	CS-332-10
J704	Card-edge Connector	MOL	09-52-3102	CS-332-10
J705	Card-edge Connector	MOL	09-52-3102	CS-332-10
	"800" SERIES (Schematic 27939D) (PC-410)			
P801	Assembly Cable	K-I	---	28714A

RELAYS (K)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 27935E) (PC-412)			
K501	Relay	P&B	R10-E3738-1	RL-51
K502	Relay	CCC	3206-5-911	RL-52
K503	Relay	CCC	K-1	RL-54

CONNECTORS (P)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"300 SERIES (Schematic 27935E) (PC-412)			
P301	Wire Assembly (violet)	K-1	---	---
	"400 SERIES (Schematic 27938D) (PC-412)			
P401	3-Pins	MOL	A-2391-5A	CS-288-5
P402	3-Pins	K-1	---	CS-339-4
P403	2-Pins	K-1	---	CS-339-2
P404	3-Pins	MOL	A-2391-5A	CS-288-5
P405				
	"500" SERIES (Schematic 27935E) (PC-412)			
P501	Connector	K-1	---	28625A
P502	7-Pins	MOL	09-64-1104	CS-338-7
P503	2-Pins	MOL	09-64-1104	CS-338-2
P504	5-Pins	MOL	09-64-1104	CS-338-5
P505	6-Pins	MOL	09-64-1104	CS-338-6
	"600" SERIES (Schematic 27937D) (PC-412)			
P601		BRG	65507-136	CS-339-13
P602	NOT USED			
P603				24249A
	"700" SERIES (Schematic 28209E) (PC-421)			
P701	4 Pins	K-1		24249A
	"900" SERIES (Schematic 27935E) (PC-412)			
P901	NOT USED			
P902	10-Pins	MOL	09-64-1104	CS-338-1
P903	10-Pins	MOL	09-64-1104	CS-338-1
P904	10-Pins	MOL	09-64-1104	CS-338-1
P905	10-Pins	MOL	09-64-1104	CS-338-1

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
Q001	Dual PNP, Case TO-52	A-D	AD820	TG-121
Q002	NPN, Case TO-106	F-I	2N5134	TG-65
Q003	NPN, Case TO-106	F-I	2N5134	TG-65
	"100" SERIES (Schematic 27936F) (PC-412)			
Q101	PNP, Case TO-92	MOT	2N3905	TG-53
Q102	NPN, Case TO-5	INT	IT122	TG-73
Q103	NPN, Case TO-106 (Sel. TG-39)	K-I	---	28234A
Q104	P-Chan. Enhancement Type, MOS FET, Case TO-72	SIL	IT122	TG-73
Q105	Dual NPN, Case TO-5	INT	E411	TG-118
Q106	Dual FET	SIL	ITS3538	TG-88
Q107	FET, Case TO-18	INT	ITE4392	TG-77
Q108	N-Channel JFET	INT	ITS3538	TG-88
Q109	FET, Case TO-18	INT	ITS3538	TG-88
Q110	FET, Case TO-18	INT	ITS3538	TG-88
Q111	FET, Case TO-18	INT	ITS3538	TG-88
Q112	FET, Case TO-18	INT	ITS3538	TG-88
Q113	FET, Case TO-18	INT	ITS3538	TG-88
Q114	FET, Case TO-18	INT	ITS3538	TG-88
	"200" SERIES (Schematic 27936F) (PC-412)			
Q201	N-Chan, FET, Case TO-92	NAT	PN4392	TG-129
Q202	FET, Case TO-18	INT	ITS3538	TG-88
Q203	N-Chan, J-FET, Case TO-92	NAT	PN4393	TG-130
Q204	N-Channel JFET	INT	ITE4392	TG-77
Q205	N-Chan FET, Case TO-92	NAT	PN4393	TG-130
Q206	NPN, Case TO-106	F-I	2N3565	TG-39
Q207	PNP, Case TO-92	MOT	2N3905	TG-53
Q208	PNP, Case TO-92	MOT	2N3905	TG-53
Q209	N-Chan, Fet, Case TO-92	NAT	PN4392	TG-128
Q210	N-Chan, Fet, Case TO-92	NAT	PN4392	TG-128
Q211	N-Chan, Fet, Case TO-92	NAT	PN4392	TG-128
Q212	N-Chan, FET, Case TO-92	NAT	PN4392	TG-128
Q213	NPN, Case TO-106 (Selected TG-39)	K-I	...	28234A
Q214	NPN, Case TO-106 (Selected TG-39)	K-I	...	28234A
Q215	NPN, CASe TO-106 (Selected TG-39)	K-I	...	28234A
Q216	PNP, Case TO-92	MOT	2N3905	TG-53
	"400" SERIES (Schematic 27938D) (PC-412)			
Q401	PNP, Power Type, Case	MOT	MJE-710	TG-125
Q402	NPN, Power Type, Case	MOT	MJE-710	TG-124
Q403	NPN, Power Type, Case	MOT	MJE-710	TG-124

TRANSISTORS (Q) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 27935E) (PC-412)			
Q501	FET, Case TO-18.	INT	ITS3538	TG-88
	"600" SERIES (Schematic 27937D) (PC-412)			
Q601	NOT USED	...	...	...
Q602	FET, Case TO-18.	INT	ITS3538	TG-88
Q603	Dual N-Channel JFET.	INT	2N6483	TG-116
Q604	Dual P-Chan. MOS-FET, Case TO-99 .	G-I	955-004	TG-94
	"700" SERIES (Schematic 28209E) (PC-421)			
Q701	NPN, Case TO-106	F-I	2N3565	TG-39
Q702	PNP, Case TO-92.	MOT	2N3906	TG-84
Q703	PNP, Case TO-92.	MOT	2N3906	TG-84
Q704	NPN, Case TO-106	F-I	2N3565	TG-39
Q705	NPN, Case TO-106	F-I	2N3565	TG-39
Q706	PNP, Case TO-92.	MOT	2N3906	TG-84
Q707	PNP, Case TO-92.	MOT	2N3906	TG-84
Q708	NPN, Case TO-92.	MOT	2N3906	TG-47
Q709	PNP, Case TO-92.	MOT	2N3904	TG-84
Q710	NPN, Case TO-106	F-I	2N3565	TG-39
Q711	NPN, Case TO-106	F-I	2N3565	TG-39
Q712	PNP, Case TO-92	MOT	2N3906	TG-84
Q713	PNP, Case TO-92	MOT	2N3906	TG-84
Q714	PNP, Case TO-92	MOT	2N3906	TG-84
Q715	PNP, Case TO-92	MOT	2N3906	TG-84
Q716	NPN, Case	F-I	2N3643	TG-123
Q717	NPN, Case TO-92	MOT	2N3904	TG-47
Q718	PNP, Case TO-92	MOT	2N3906	TG-84
Q719	NPN, Case TO-106	F-I	2N3565	TG-39
Q720	PNP, Case TO-92	MOT	2N3906	TG-84
Q721	NPN, Case TO-106	F-I	2N3565	TG-39
Q722	PNP, Case TO-92	MOT	2N3906	TG-84
	"800" SERIES (Schematic 27939D) (PC-410)			
Q801	NPN, Case.	F-I	2N3643	TG-123
Q802	PNP, Case R-110.	F-I	S17638	TG-33
Q803	PNP, Case R-110.	F-I	S17638	TG-33
Q804	PNP, Case R-110.	F-I	S17638	TG-33
Q805	PNP, Case R-110.	F-I	S17638	TG-33
Q806	PNP, Case R-110.	F-I	S17638	TG-33
Q807	PNP, Case R-110.	F-I	S17638	TG-33
Q808	PNP, Case R-110.	F-I	S17638	TG-33
Q809	PNP, Case R-110.	F-I	S17638	TG-33
Q810	PNP, Case TO-106	F-I	2N4355	TG-90
Q811	PNP, Case TO-106	F-I	2N4355	TG-90
Q812	PNP, Case TO-106	F-I	2N4355	TG-90
Q813	PNP, Case TO-106	F-I	2N4355	TG-90
Q814	PNP, Case TO-106	F-I	2N4355	TG-90
Q815	PNP, Case TO-106	F-I	2N4355	TG-90

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
R001	6.04KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-6.04KΩ	R-88-6.04K
R002	Thick Film Resistor Network	K-1	...	RF-47
R003	10KΩ, 10%, 1/4W, Comp	A-B	CB-103-10%	R-76-10K
R004	18KΩ, 10%, 1/4W, Comp	A-B	CB-183-10%	R-76-18K
R005	6.8K, 10%, 1/4W, Comp	A-B	CB-682-10%	T-76-6.8K
R006	5.49KΩ, 1%, 1/8W, Comp.	IRC	CEA-T0-5.49KΩ	R-88-5.49K
R007	7.68KΩ, 1%, 1/8W, Comp.	IRC	CEA-T0-7.68KΩ	R-88-7.68K
R008	10MΩ, 10%, 1/4W, Comp	A-B	CB-106-10%	R-76-10M
R009	100Ω, 1%, 1/8W, MTF	IRC	CEA-T0-100	R-88-100
R010	1.5KΩ, 1%, 1/8W, MTF.	IRC	CEA-T0-1.5KΩ	R-88-1.5K
R011	4.22KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-4.22KΩ	R-88-4.22K
R012	1.15KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-1.15KΩ	R-88-1.15K
R013	49.9KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-49.9KΩ	R-88-49.9K
R014	15Ω, 10%, 1/4W, Comp.	A-B	CB-150-10%	R-76-15
	"100" SERIES (Schematic 27936F) (PC-412)			
R101	280Ω, 1%, 1/8W, MTF	IRC	CEA-T0-280	R-88-280
R102	280Ω, 1%, 1/8W, MTF	IRC	CEA-T0-280	R-88-280
R103	1KΩ, Potentiometer, 0.5W.	BEC	72PMR	RP-97-1K
R104	6.336KΩ, 0.1%, 1/8W, MTF.	DLE	MFF-1/8-6.336K	R-168-6.336K
R105	150KΩ, 1%, 1/8W, MTF.	IRC	CEA-T0-150K	R-88-150K
R106	470KΩ, 10%, 1/4W, Comp.	A-B	CB-471-10%	R-76-470
R107	470Ω, 10%, 1/4W, Comp	A-B	CB-471-10%	R-76-470
R108	200KΩ, 1%, 1/8W, MTF.	IRC	CEA-T0-200K	R-88-200K
R109	Thick Film Resistor Network	K-1	...	TF-49
R110	Thick Film Resistor Network	K-1	...	TF-46
R111	43KΩ, 5%, 1/4W, Comp.	MEP	CR-25-43K	R-248-43K
R112	43KΩ, 5%, 1/4W, Comp.	MEP	CR-25-43K	R-248-43K
R113	10KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-10K
	"200" SERIES (Schematic 27936F) (PC-412)			
R201	5KΩ, 0.5W, Var	BEC	72PMR-5K	RP-97-5K
R202	374Ω, 1%, 1/8W, MTF	IRC	CEA-T0-374	R-88-374
R203	7.5KΩ, 1%, 1/8W, MTF.	DLE	MFF-1/8-7.5K	R-168-7.5K
R204	7.5KΩ, 1%, 1/8W, MTF.	DLE	MFF-1/8-7.5K	R-168-7.5K
R205	28KΩ, 1/8W, 200V.	DLE	MFF-1/8-28K	R-246-28K
R206	Part of 28040B		...	...
R207	Part of 28040B		...	...
R208	20KΩ, Potentiometer	BEC	72PMR-20K	RP-97-20K
R209	500Ω, Potentiometer, 0.5W	BEC	72PMR-500	RP-97-500
R210	Thick Film Resistor Network	K-1	...	TF-56
R211	23.2KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-23.2K	R-88-23.2K
R212	332KΩ, 0.1%, 1/8W, MTF	DLE	MFF-1/8-332K	R-168-332K
R213	200KΩ, Potentiometer, 0.5W	BEC	72PMR-200K	RP-97-200K
R214	Thick Film Resistor Network	K-1	...	TF-51
R215	Thick Film Resistor Network	K-1	...	TF-45
R216	909Ω, 1%, 1/8W, MTF	IRC	CEA-T0-909	R-88-909

RESISTORS (R) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 27936F) (PC-412)			
R217	10KΩ, Potentiometer, 0.5W	BEC	72PMR-200K	RP-97-10K
R218	Thick Film Resistor Network	K-I	...	TF-50
R219	1.8KΩ, 1%, 1/8W, MTF.	IRC	CEA-T0-1.8K	R-88-1.8K
R220	10KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-10K	R-88-10K
R221	200Ω, 1%, 1/8W, MTF	IRC	CEA-T0-200	R-88-200
R222	200KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-200K	R-88-200K
R223	39KΩ, 10%, 1/4W, Comp	A-B	CB-393-10%	R-76-39K
R224	Thick Film Resistor Network	K-I	...	TF-48
R225	10KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-10K	R-88-10K
R226	210KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-210K	R-88-210K
R227	22KΩ, 10%, 1/4W, Comp	IRC	CB-100-10%	R-76-22K
R228	22KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-22K
R229	22KΩ, 5%, 1/4W, Comp.	MEP	CR-25-22K	R-248-22K
R230	Thick Film Resistor Network	K-I	...	TF-60
R231	8.2KΩ, 10%, 1/4W, Comp.	A-B	CB-822-10%	R-76-8.2K
R232	47KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-47K
R233	47KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-47K
R234	100KΩ, 10%, 1/4W, Comp.	A-B	CB-101-10%	R-76-100K
R235	100KΩ, 10%, 1/4W, Comp.	A-B	CB-101-10%	R-76-100K
	"400" SERIES (Schematic 27938D) (PC-412)			
R401	100Ω, GB-10%, Comp	A-B	GB, 10%	R-2-100
R402	680Ω, EB-10%, Comp	A-B	EB, 10%	R-1-680
R403	270Ω, EB-10%, Comp	A-B	CMF 1/4; T-1, 1%	R-1-270
R404	649Ω, 1/4, T-1, 1%, MTF	DLE	CMF 1/4; T-1, 1%	R-94-649
R405	232Ω, 1/4, T-1, 1%, MTF	DLE	CMR 1/4; T-1, 1%	R-94-232
R406	82Ω, HB-10%, 82 , Comp	A-B	HB, 10%	R-3-82
R407	649Ω, 1/4, T-L, 1%, MTF	DLE	CMF 1/4; T-1, 1%	R-94-649
R408	680Ω, EB-10%, Comp	A-B	EB, 10%	R-1-680
	"500" SERIES (Schematic 27935E) (PC-412)			
R501	NOT USED	...	...	...
R502	NOT USED	...	...	...
R503	49.875KΩ	K-I	...	R-259-49.875K
R504	5.455KΩ.	K-I	...	R-255-5.455K
R505	500Ω, Potentiometer, 0.5W	BEC	72PMR-500	RP-97-500
R506	100Ω, Potentiometer, 0.5W	BEC	72PMR-100	RP-97-100
R507	2.7Ω, 10%, 1/4W, Comp	BEC	CB-2R7-10%	R-76-2.7
R508	1MΩ, 10%, 1/4W, Comp	A-B	CB-105-10%	R-76-1M
R509	200KΩ, Potentiometer, 0.5W	BEC	72PMR-200K	RP-97-200K
R510	1MΩ, 1%, 1/8W, MTF	IRC	CEA-T0-1M	R-88-1M
R511	2.7Ω, 10%, 1/4W, Comp	A-B	CB-2R7-10%	R-76-2.7
R512	1MΩ, 1%, 1/8W, Comp	IRC	CEA-T0-1M	R-88-1M
R513	200KΩ, Potentiometer, 0.5W	BEC	72PMR-200K	RP-97-200K
R514*	NOT USED	...	...	...
R515*	4.875MΩ, 1%.	K-I	...	R-259-4.875M
R516	49.9KΩ, 1%, 1/8W, Comp	IRC	CEA-T0-49.9K	R-88-49.9K

RESISTORS (R) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 27935E) (PC-412)			
R517	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R518	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R519	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R520	2MΩ, Film Res. 1%	CAD	ML212 1%, 2 Meg	R-253-2M
R521	47KΩ, HB-10%, Comp	A-B	HB, 1%	R-3-47K
R522	27KΩ, 1/2W, 10%, Comp	A-B	EB, 1%	R-1-27K
R523	75KΩ, 1%, 5W	PRE	5M2812	R-200-75K
R524	75KΩ, 1%, 5W	PRE	5M2812	R-200-75K
R525	150KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-150K	R-88-150K
	"600" SERIES (Schematic 27937D) (PC-412)			
R601	4.99KΩ, 1/8W, 1%, MTF	DLE	CMF 1/10; T-9, 1%	R-177-4.99K
R602	4.02KΩ, 1/8W, 1%, MTF	DLE	CMF 1/10; T-9, 1%	R-177-4.02K
R603	2KΩ, .3W, 2%, POT	BRN	3279-W-1-202	RP-94-2K
R604	100Ω, 0.5W, 3%, POT	BRN	3386F-1-101	RP-97-100
R605	100KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-100K
R606	100KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-100K
R607	5.6KΩ, 10%, 1/4W, Comp	MEP	CR25; 5%	R-76-5.6K
R608	NOT USED			NOT USED
R609	49.9KΩ, 1/8W, 1%, MTF	DLE	CMF 1/10; T-9, 1%	R-177-49.9K
R610	40.2KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-9, 1%	R-168-40.2K
R611	40.2KΩ, 1/8W, 1%, MTF	DLE	CMF 1/10; T-9, 1%	R-168-40.2K
R612	1KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-9, 1%	R-88-1K
R613	1MΩ, 1/8W, MTF	IRC	CEA-T0-1M	R-88-1M
R614	1MΩ, 1/8W, 1%, MTF	IRC	CEA-T0-1M	R-88-1M
R615	9.85KΩ, 0.25%, 0.25W, WW	KEL	EP21	R-261-9.85K
R616	100Ω, 0.25%, 0.25W, WW	KEL	EP21	R-261-100K
R617	1MΩ, 1/8W, 1%, MTF	IRC	CEA-T0-1M	R-88-1M
R618	3.3KΩ, EB-1%, Comp	A-B	EB, 1%	R-1-3.3K
R619	3.3KΩ, HB, 1%, Comp	A-B	HB, 1%	R-3-3.3K
R620	3.3K, HB, 1%, Comp	A-B	HB, 1%	R-3-3.3K
R621	3.3KΩ, HB, 1%, Comp	A-B	HB, 1%	R-3-3.3K
R622	Thick Film Resistor Network	K-I	...	TF-59
R623	50KΩ, 2W, 5%, POT	K-I	...	RP-115-50K
R624	1.1KΩ, 1/8W, 1%, MTF	DLE	CMF 1/10; T-1, 1%	R-88-1.1K

* Part of Matched Set, Keithley Part No. R-259.

RESISTORS (R) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"700" SERIES (Schematic 28209E) (PC-421)			
R701	4.7KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-4.7K
R702	15KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-15K
R703	27KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-27K
R704	22KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-22K
R705	22KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-22K
R706	4.7KΩ, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-4.7K
R707	3.9KΩ, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-3.9K
R708	4.7KΩ, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-4.7K
R709	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R710	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R711	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R712	47KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-47K
R713	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R714	33KΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-33K
R715	8.2KΩ, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-8.2K
R716	15.8KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-15.8K	R-88-15.8K
R717	11.8KΩ, 1%, 1/8W, MTF	IRC	CEA-T0-11.8K	R-88-11.8K
R718	43KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-248-43K
R719	100KΩ, 10%, 1/4W, Comp.	A-B	CB-104-10%	R-76-100K
R720	2.2KΩ, 10%, 1/4W, Comp.	A-B	CB-332-10%	R-76-2.2K
R721	2.2KΩ, 10%, 1/4W, Comp.	A-B	CB-332-10%	R-76-2.2K
R722	10kΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-248-10K
R723	2.2KΩ, 10%, 1/4W, Comp.	A-B	CB-332-10%	R-76-2.2K
R724	15.8KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-15.8K
R725	11.8KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-11.8K
R726	2.2KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-2.2K
R727	1.8KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-1.8K
R728	2.2KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-2.2K
R729	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R730	12KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-12K
R731	8.2KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-8.2K
R732	12KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-12K
R733	8.2KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-8.2K
R734	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R735	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R736	43KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-43K
R737	24.3KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-24.3K
R738	17.4KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-17.4K
R739	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R740	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R741	10kΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R742	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R743	2.7KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-2.7K
R744	4.7KΩ, 10%, 1/4W, Comp.	MEP	CR25, 5%	R-76-4.7K
R745	150Ω, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-150
R746	270Ω, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-270
R747	100Ω, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-100
R748	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-10K
R749	10.7KΩ, 1%, 1/8W, Comp.	DLE	CMF 1/10; T-1, 1%	R-88-10.7K

RESISTORS (R) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"700" SERIES (Schematic 28209E) (PC-421)			
R750	4.32KΩ, 1%, 1/8W, Comp.	DLE	CMF 1/10; T-1, 1%	R-88-4.32K
R751	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R752	11.8KΩ, 1%, 1/8W, Comp.	DLE	CMF 1/10; T-1, 1%	R-88-11.8K
R753	68KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-68K
R754	100Ω, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-100
R755	3.24KΩ, 10%, 1/8W, Comp	DLE	CMF 1/10, T-1, 1%	R-88-3.24K
R756	20KΩ, .5W, 3%, POT.	BRN	203-3386F-1-2	RP-97-20K
R757	33KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-33K
R758	33KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-33K
R759	56KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-56K
R760	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R761	11.8KΩ, 1%, 1/8W, Comp	DLE	CMF 1/10; T-1, 1%	R-88-11.8K
R762	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R763	47KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-47K
R764	10KΩ, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-10K
R765	8.2KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-8.2K
	"800" SERIES (Schematic 27939D) (PC-410)			
R801	62Ω, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-62
R802	Thick Film Resistor Network	BEC	898-3-R62	RF-43
R803	1Ω, 5%, 1/4W	MEP	CR25, 5%	R-76-1
R804	1.8KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1.8K
R805	33Ω, 5%, 1/4W	MEP	CR25, 5%	R-76-33
R806	Thick Film Resistor Network	K-1	...	TF-42
R807	75Ω, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-75
R808	2.2Ω, 5%, 1/4W, Comp.	MEP	CR25, 5%	R-248-2.2
R809	39KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-39K
R810	22KΩ, 10%, 1/4W, Comp	MEP	CR25, 5%	R-76-22K
	"900" SERIES (Schematic 27935E) (PC-412)			
R901	133KΩ, 1%, 1/8W, MTF.	DLE	CMF 1/10; T-1, 1%	R-88-133K
R902	133KΩ, 1%, 1/8W, MTF.	DLE	CMF 1/10; T-1, 1%	R-88-133K
R903	10KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-10K
R904	49.9KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-49.9K

SWITCHES (S)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"300" SERIES (Schematic 27935E) (PC-412)			
S301	Pushbutton Switch.	K-I	---	SW-395
S302	Rotary Switch.	K-I	---	SW-396
	"400" SERIES (Schematic 27938D) (PC-412)			
S401	Line Switch.	K-I	---	SW-397
S402	Line Switch.	K-I	---	SW-397

TRANSFORMERS (T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 27938D) (PC-412)			
T401	Transformer.	K-I	---	TR-165

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
U001	Transistor Array, 14-Pin DIP . . .	RCA	CA3086	IC-53
U002	Dual D-Type Flip-Flop; 14-Pin DIP.	T-I	SN74LS74N	IC-144
U003	Dual D-Type Flip-Flop; 14-Pin DIP.	T-I	SN74LS74N	IC-144
U004	Hex Inverter, 16-Pin DIP	RCA	CD4049AE	IC-106
U005	Timing, 8-Pin DIP.	SIG	NE555V	IC-71
	"100" SERIES (Schematic 27936F) (PC-412)			
U101	Op-Amp, 8-Pin DIP.	NAT	LM308N	IC-99
U102	Custom Comparator.	K-I	---	LSI-5
U103	Large Scale Integrated Circuit ...	K-I	---	LSI-4
	"200" SERIES (Schematic 27936F) (PC-412)			
U201	Selected Transistor Array. . . .	K-I	---	28090A
U202	Selected Op-Amp.	K-I	---	IC-132
	"600" SERIES (Schematic 27937D) (PC-412)			
U601	Op-Amp, 8-Pin, Case TO-99. . . .	NAT	LM308A	IC-49
U602	Op-Amp, 8-Pin, Case TO-99. . . .	NAT	LM308A	IC-49

VOLTAGE REGULATORS (VR) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"700" SERIES (Schematic 28209E) (PC-421)			
U701	COS/MOS Multifunction Expandable 8-Input Gate 16-Pin DIP.	RCA	CD4048AE	IC-148
U702	COS/MOS Presettable Divide-by-N-Counter, 16-Pin DIP	RCA	CD4018AE	IC-145
U703	COS/MOS Quad Bilateral Switch, 14-Pin DIP.	RCA	CD4066AE	IC-149
U704	Hex Buffer, 16-Pin DIP.	RCA	CD4050AE	IC-107
U705	"D" Type Flip-Flop, 14-Pin DIP.	RCA	CD4013AE	IC-103
U706	COS/MOS And Gates, Triple 3-Input 14-Pin DIP.	RCA	CD4073BE	IC-150
U707	Quad 2-Input Nand Gate, 14-Pin DIP	RCA	CD4011AE	IC-102
U708	COS/MOS 8-Stage Static Shift Register, 16-Pin DIP.	RCA	CD4021AE	IC-130
U709	Hex Inverter, 16-Pin DIP.	RCA	CD4049AE	IC-106
U710	COS/MOS AND Gates, Triple 3-Input, 14-Pin DIP	RCA	CD4073BE	IC-150
U711	Hex Inverter, 16-Pin DIP.	RCA	CD4049AE	IC-106
U712	Hex Inverter, 16-Pin DIP.	RCA	CD4049AE	IC-106
U713	"D" Type Flip-Flop, 14-Pin DIP.	RCA	CD4013AE	IC-103
U714	COS/MOS Multifunction Expandable 8-Input Gate; 16-PIN DIP	RCA	CD4022AE	IC-146
U715	COS/MOS Multifunction Expandable 8-Input Gate; 16-Pin DIP	RCA	CD4022AE	IC-146
U716	COS/MOS Divide-by-8-Counter/ Divider, 16-Pin DIP	RCA	CD4046AE	IC-147
	"800" SERIES (Schematic 27939D) (PC-410)			
U801	8-Bit Parallel-Out, Serial Shift Register, 14-Pin DIP.	T-I	SN74LS164	IC-127
	"900" SERIES (Schematic 27935E) (PC-412)			
U901	Op-Amp, 8-Pin DIP	NAT	LM308N	IC-99

VOLTAGE REGULATORS (VR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig	Keithley Part No.
	"000" SERIES (Schematic 27936F) (PC-412)			
VR001	Zener, 9.1V, 400mW.	DIC	1N960B	DZ-55

VOLTAGE REGULATORS (VR) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"100" SERIES (Schematic 27936F) (PC-412)			
VR101	Zener, 9.1V, 400mW.	DIC	1N960B	DZ-55
VR102	Zener, 6.2V, 1/4W	DIC	1N827A	DZ-48
	"200" SERIES (Schematic 27936F) (PC-412)			
VR201	Reference Diode (Part of Matched Set)	...		28040B
VR202	Reference Diode (Part of Matched Set)	...		28040B
VR203	Zener, 12V, 400mW	DIC	1N963B	DZ-54
	"400" SERIES (Schematic 27938D) (PC-412)			
VR401	Voltage Regulator, 5V, Case TO-220.	MOT	MC7805CP	IC-93
VR402	Voltage Regulator, 15V, Case TO-66	RAY	RC4195TK	IC-128
VR403	Zener, 9.1V, 1W	DIC	1N4739A	DZ-56
VR404	Voltage Regulator, 3-Terminal Pos, Case TO-92	NAT	LM340LAZ-8.0	IC-164
VR405	Zener diode, 20V, 1W	MOT	1N4747	DZ-25
VR406	Zener diode, 20V, 1W	MOT	1N4747	DZ-25
	"700" SERIES (Schematic 28209E) (PC-421)			
VR701	Zener, 12V, 400mW.	DIC	1N963B	DZ-54

JUMPERS (W)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 27936F) (PC-412)			
W201	Wire	ERI	333	J-3
	'400" SERIES (Schematic 27938D) (PC-412)			
W401	Wire	---	---	---
W402	Wire	---	---	---
W403	Wire	---	---	---

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CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
C1001	0.01µF, 500V, CerD	.ERI	871-Z5U0-103M	C-22-.01M
C1002	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1003	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1004	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1005	1550µF, 25V, EAL	.RIC	MD16C1550258P	C-272-1550M
C1006	0.01µF, 500V, CerD	.ERI	871-Z5U0-103M	C-22-.01M
C1007	0.01µF, 16V, CerD	.CLB	UK16-103	C-238-.01M
C1008	1000pF, 1000V, CerD.	.ERI	808-000-Z5R0-102K	C-64-1000P
C1009	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1010	39µF, 15V, ETT	.C-I	TD401539610	C-228-39M
C1011	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1012	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1013	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1014	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1015	10µF, 20V, ETT	.ITT	TAP/F010F200	C-179-10M
C1016	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1017	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-.01M
C1018	100µV, 15V, ETT.	.C-I	TD501510710	C-228-100M
	"1100" SERIES (Schematic 28019E) (PC-416)			
C1101	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C1102	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C1103	1.2µF, 20%, 20V.	.C-I	TD1-20-125-20	C-179-1.2M
C1104	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C1105	0.01µF, 16V, CerD.	.CLB	UK16-103	C-238-0.01M
C1106	220pF, 1000V, CerD	.CRL	DD-221	C-64-220P
C1107	1000pF, 1000V, CerD.	.ERI	808-000-Z5R0-102K	C-64-1000P

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
CR1001	Rectifier, 75mA, 75V	.T-I	IN914	RF-28
CR1002	Bridge Rectifier, 100V, 2A . . .	.E-D	PD10	RF-36
	"1100" SERIES (Schematic 28019E) (PC-416)			
CR1101	Rectifier, 75mA, 75V	.T-I	IN914	RF-28

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
J1001	Connector, Housing 5-Pins	BRG	20370	CS-251
J1002	NOT USED			
J1003	Connector, 2-Pin	BRG	65039-035	CS-266
	"1100" SERIES (Schematic 28019E) (PC-416)			
J1101	NOT USED			
J1102	NOT USED			
J1103	NOT USED			
J1104	Connector, 10-Pins	MOL	09-52-3102	CS-332-10
J1105	Connector, 12-Pins	MOL	09-52-3122	CS-332-12

CONNECTORS (P)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
P1001	NOT USED			
P1002	NOT USED			
P1003	NOT USED			
P1004	Connector, 10-pins	MOL	09-67-1104	CS-331-10
P1005	Connector, 12-pins	MOL	09-67-1124	CS-331-12
P1006	Card-edge, 40-pins (Model 1727)	MMM	3464-0000	CS-294-3
	"1100" SERIES (Schematic 28019E) (PC-416)			
P1101	Card-edge, 26-pins (Model 1727)	MMM	3462-0000	CS-294-1

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E)			
Q1001	NPN, Case TO-106	F-I	2N5134	TG-65
Q1002	NPN, Case TO-106	F-I	2N5134	TG-65
Q1003	NPN, Case TO-106	F-I	2N5134	TG-65
Q1004	NPN, Case TO-106	F-I	2N5134	TG-65
Q1005	NPN, Case TO-106	F-I	2N5134	TG-65
Q1006	NPN, Case TO-106	F-I	2N5134	TG-65
Q1007	NPN, Case TO-106	F-I	2N5134	TG-65
Q1008	NPN, Case TO-106	F-I	2N5134	TG-65
Q1009	NPN, Case TO-106	F-I	2N5134	TG-65
Q1010	NPN, Case TO-106	F-I	2N5134	TG-65
Q1011	NPN, Case TO-106	F-I	2N5134	TG-65
Q1012	NPN, Case TO-106	F-I	2N5134	TG-65
Q1013	NPN, Case TO-106	F-I	2N5134	TG-65
Q1014	NPN, Case TO-106	F-I	2N5134	TG-65
Q1015	NPN, Case TO-106	F-I	2N5134	TG-65

TRANSISTORS (Q) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
Q1016	NPN, Case TO-106	F-I	2N5134	TG-65
Q1017	NPN, Case TO-106	F-I	2N5134	TG-65
Q1018	NPN, Case TO-106	F-I	2N5134	TG-65
Q1019	NPN, Case TO-106	F-I	2N5134	TG-65
Q1020	NPN, Case TO-106	F-I	2N5134	TG-65
Q1021	NPN, Case TO-106	F-I	2N5134	TG-65
Q1022	NPN, Case TO-1-6	F-I	2N5134	TG-65
Q1023	NPN, Case TO-106	F-I	2N5134	TG-65
Q1024	NPN, Case TO-106	F-I	2N5134	TG-65
Q1025	NPN, Case TO-106	F-I	2N5134	TG-65
Q1026	NPN, Case TO-106	F-I	2N5134	TG-65
Q1027	NPN, Case TO-106	F-I	2N5134	TG-65
Q1028	NPN, Case TO-106	F-I	2N5134	TG-65
Q1029	NPN, Case TO-106	F-I	2N5134	TG-65
Q1030	NPN, Case TO-106	F-I	2N5134	TG-65
Q1031	NPN, Case TO-106	F-I	2N5134	TG-65
Q1032	NPN, Case TO-106	F-I	2N5114	TG-65
Q1033	NPN, Case TO-106	F-I	2N5134	TG-65
Q1034	NPN, Case TO-106	F-I	2N5134	TG-65
Q1035	NPN, Case TO-106	F-I	2N5134	TG-65
Q1036	NPN, Case TO-106	F-I	2N5134	TG-65
Q1037	NPN, Case TO-106	F-I	2N5134	TG-65
	"1100" SERIES (Schematic 28019E) (PC-416)			
Q1101	NPN, Case TO-106	F-I	2N5134	TG-65

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
R1001	Resistor Network, Thick Film	K-I	---	TF-53
R1002	Resistor Network, Thick Film	K-I	---	TF-53
R1003	Resistor Network, Thick Film	K-I	---	TF-53
R1004	Resistor Network, Thick Film	K-I	---	TF-53
R1005	Resistor Network, Thick Film	K-I	---	TF-53
R1006	1KΩ, 10%, 1/4W, Comp	A-B	CB-102-10%	R-76-1K
R1007	32.4KΩ, 1%, 1/8W, MTF.	IRC	CEA-TO-32.4K	R-88-32.4K
R1008	1MΩ, 10%, 1/4W, Comp	A-B	CB-105-10%	R-76-1M
R1009	3.9KΩ, 10%, 1/4W, Comp	A-B	CB-392-10%	R-76-3.9K
R1010	3.9KΩ, 10%, 1/4W, Comp	A-B	CB-392-10%	R-76-3.9K
R1011	154Ω, 1%, 1/8W, MTF.	IRC	CEA-TO-154	R-88-154
R1012	3.9KΩ, 10%, 1/4W, Comp	A-B	CB-392-10%	R-76-3.9K

RESISTORS (R) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
R1013	154Ω, 1%, 1/8W, Comp	IRC	CEA-T0-154	R-88-154
R1014	154Ω, 1%, 1/8W, MTF.	IRC	CEA-T0-154	R-88-154
R1015	154Ω, 1%, 1/8W, MTF.	IRC	CEA-T0-154	R-88-154
R1016	10Ω, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-10
	"1100" SERIES (Schematic 28019E) (PC-416)			
R1101	11KΩ, 1%, 250V, 1/8W	IRC	CEA-T0-11KΩ	R-88-11K
R1102	Resistor Network, Thick Film	K-I	---	TF-54
R1103	Resistor Network, Thick Film	K-I	---	TF-54
R1104	Resistor Network, Thick Film	K-I	---	TF-54
R1105	Resistor Network, Thick Film	K-I	---	TF-54
R1106	6.65KΩ, 1%, 1/8W	IRC	CEA-T0-6.5KΩ	R-88-6.65
R1107	10KΩ, 1%, 1/8W	IRC	CEA-T0-10KΩ	R-88-10K

TRANSFORMERS (T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
T1001	Transformer.	K-I	---	TR-164

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
U1001	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1002	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1003	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1004	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1005	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1006	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1007	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1008	COS/MOS Dual 4-Stage Static Shift Register	RCA	CD4015AE	IC-136
U1009	COS/MOS Dual 4-Stage Static Shift Register	RCA	CD4015AE	IC-136
U1010	COS/MOS Dual 4-Stage Static Shift Register	RCA	CD4015AE	IC-136
U1011	COS/MOS Dual 4-Stage Static Shift Register	RCA	CD4015AE	IC-136
U1012	Quad 2-Input AND, 14-Pin DIP	RCA	CD4015AE	IC-138
U1013	Quad 2-Input AND, 14-Pin DIP	RCA	CD4081BE	IC-138
U1014	Quad 2-Input NOR, 14-Pin DIP	RCA	CD4001AE	IC-138
U1015	Dual D-Type Flip-Flop 14-Pin DIP	RCA	CD4013AE	IC-103
U1016	COS/MOS Hex Inverter, 14-Pin DIP	RCA	CD4069BE	IC-139
U1017	Timing Logic, 8-Pin DIP	SIG	NE555V	IC-71
U1018	Opto-Isolator, 8-Pin DIP	H-P	HP5082-4351	IC-142

INTEGRATED CIRCUITS (U) (CON'T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E) (PC-415)			
U1019	Opto-Isolator, 8-Pin DIP	H-P	HP5082-4351	IC-142
U1020	Opto-Isolator, 8-Pin DIP	H-P	HP5082-4351	IC-142
U1021	Opto-Isolator, 8-Pin DIP	H-P	HP5082-4351	IC-142
	"1100" SERIES (Schematic 28019E) (PC-416)			
U1101	Hex Inverters, Open Collector Output	T-I	SN74LS05N	IC-141
U1102	Hex Inverters, Open Collector Output	T-I	SN74LS05N	IC-141
U1103	Hex Inverters, Open Collector Output	T-I	SN74LS05N	IC-141
U1104	Positive-NAND Gates and Inverters/Totem-pole Outputs	T-I	SN74LS14N	IC-137
U1105	Hex Inverters, Open Collector Outputs	T-I	SN74LS05N	IC-141
U1106	Dual D-Type Flip-Flop, 14-Pin DIP	RCA	CD4013AE	IC-103
U1107	Quad 2-Input NOR, 14-Pin DIP . . .	RCA	CD4001AE	IC-108
U1108	COS/MOS 8-Stage Static Shift Register	RCA	CD4021AE	IC-130
U1109	Quad 2-Input AND, 14-Pin DIP . . .	RCA	CD4081BE	IC-138
U1110	COS/MOS Dual 4 Input NAND Gates.	RCA	CD4012AE	IC-140
U1111	Six COS/MOS Hex Inverter	RCA	CD4069BE	IC-139

MODEL 1728 BATTERY PACK

BATTERIES (BT)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
BT401	Multicell, 19.2V, Nickel-Cadmium	GLD	403041	BA-31
BT402	Multicell, 19.2V, Nickel-Cadmium	GLD	403041	BA-31
BT403	Set of Seven "C" cells, 8.4 V. . .	---	---	*
*	Nickel-Cadmium, "C" cell, 1.2V (Used for BT403; Seven required)	GLD	2.02CB	BA-30

FUSES (F)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
F401	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10
F402	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10
F403	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
CR401	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR402	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR403	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR404	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR405	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR406	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR407	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR408	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR409	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR410	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
J401	5-pins	MOL	2139-5	CS-287-5
J402	5-pins	MOL	2139-5	CS-287-5

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
Q401	PNP, Case TO-5	RCA	2N4032	TG-92
Q402	NPN, Case TO-39.	MOT	2N3300S	TG-117
Q403	PNP, Case TO-5	RCA	2N4032	TG-92
Q404	NPN, Case TO-106	F-I	2N3565	TG-39
Q405	PNP, Case TO-92.	MOT	2N5087	TG-61

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
R401	13.7Ω, 1%, 1/8W, MtF	IRC	CEA-T0-13.7Ω	R-88-13.7
R402	12 kΩ, 10%, 1/2W, Comp	A-B	EB-123-10%	R-1-12K
R403	12 kΩ, 10%, 1/2W, Comp	A-B	EB-123-10%	R-1-12K
R404	13.7Ω, 1%, 1/8W, MtF	IRC	CEA-T0-13.7Ω	R-88-13.7
R405	3.3 Ω, 10%, 1/2W, Comp	A-B	EB-3R3-10%	R-1-3.3
R406	1.5 kΩ, 10%, 1/2W, Comp.	A-B	EB-152-10%	R-1-1.5K
R407	71.5 kΩ, 1%, 1/8W, MtF	IRC	CEA-T0-71.5K	R-88-71.5K
R408	100 kΩ, 10%, 1/4W, Comp.	A-B	CB-104-10%	R-76-100K
R409	2.2 kΩ, 10%, 1/4W, Comp.	A-B	CB-222-10%	R-76-2.2K
R410	76.8 kΩ, 1%, 1/8W, MtF	IRC	CEA-T0-76.8K	R-88-76.8K
R411	499 kΩ, 1%, 1/8W, MtF.	IRC	CEA-T0-499K	R-88-499K
R412	100 kΩ, 1%, 1/8W, MtF.	IRC	CEA-T0-100K	R-88-100K
R413	110 kΩ, 1%, 1/8W, MtF.	IRC	CEA-T0-110K	R-88-110K
R414	499 kΩ, 1%, 1/8W, MtF	IRC	CEA-T0-499K	R-88-499K

INTERGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C) (PC-404)			
U401	Operational Amplifier, 8-pin DIP	F-I	U9T7741393	IC-42

MODEL 1740 AC OPTION (PC-414)

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
C1201	4.7µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-4.7M
C1202	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
C1203	10µF, 20V, ETT	NCI	KNS106B0Z0K	C-179-10M
C1204	150pF, 1000V, CerD	CLB	DD-151	C-64-150P
C1205	0.1µF, 200V	ECI	625B1C104	C-221-0.1M
C1206	220µF, 6V, ETT	C-I	TD5-506277-20	C-194-220M
C1207	33pF, 1000V, CerD.	CLB	DD-330	C-64-33P
C1208	10µF, 35V, 20%	ITT	TAP/F10MFD	C-179-10M
C1209	10µF, 35V, 20%	ITT	TAP/F10MFD	C-179-10M
C1210	120µF, 20%, 10V, ETT	NCI	KNS127E010K	C-180-120M
C1211	120µF, 20%, 10V, ETT	NCI	KNS127E010K	C-180-120M
C1212	2200pF, 500V, 10%, Cer	ERI	831-Z5U-0222M	C-22-2200P
C1213	1.3/5.4pF, Trimmer CAP	EFJ	187-0303-105	C-281-1.3/5.4P
C1214	3.5/14pF, Trimmer CAP	ERI	538-006B-3.5-14	C-280-3.5/14P
C1215	16pF, 500V, MICA	ELM	RDM15CD	C-277-16P
C1216	210pF, 500V, MICA	MIC	RDM15 FD208E03	C-293-210P
C1217	2200pF, 500V, MICA	G-I	RDM15FD	C-278-2200P
C1218	0.25/1.5pF, Trim	EFJ	2730001002	C-216-.25/1.5P
C1219	0.24/1.5pF, Trim	EFJ	2730001002	C-216-.25/1.5P
C1220	0.25/1.5pF, Trim	EFJ	2730001002	C-216-.25/1.5P
C1221	10µF, 35V, 20%,	C-I	TD2-20-106-20	C-179-10M
C1222	10µF, 35V, 20%,	C-I	TD2-20-106-20	C-179-10M
C1223	10µF, 35V, 20%,	C-I	TD2-20-106-20	C-129-10M
C1224	0.22µF, 1000 V DC, MPF	S-C	M2WF	C-279-0.22M
C1225	0.33µF, 50V, CerF.	ERI	8131050651-334M	C-237-.33M
C1226	0.33µF, 50V, CerF.	ERI	8131050651-334M	C-237-.33M
C1227	0.33µF, 50V, CerF.	ERI	8131050651-334M	C-237-.33M
C1228	0.33µF, 50V, CerF	ERI	8131050651-334M	C-237-.33M
C1229	1pF, 50V, CerF.	CLB	8131050651-334M	C-282-1P

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
CR1201	Rectifier, 75mA, 75V.	F-I	1N4148	RF-28
CR1202	Rectifier, 0.2A, 70V, 0.4W.	F-I	1N4607	RF-41
CR1203	Rectifier, 0.2A, 70V, 0.4W.	F-I	1N4607	RF-41
CR1204	DIP	INT	ID101	DN-3

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
J1201	Connector	MOL	09-62-3081	CS-337-8
J1202	Connector	MOL	09-62-3081	CS-337-8

RELAYS (K)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
K1201	Relay	WAB	1170-5-2	RL-53
K1202	Relay	WAB	1170-5-2	RL-53
K1203	Relay	WAB	1170-5-2	RL-53

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
Q1201	FET, Case TO-72	SIG	SD210	TG-119
Q1202	PNP, Case TO-92	MOT	2N3905	TG-53
Q1203	Dual FET	SIL	E411	TG-118
Q1204	N-J FET	INT	ITE4391	TG-76

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
R1201	20Ω, .5W, Potentiometer	BRN	3386H-1-200	RP-111-20
R1202	100KΩ, .5W, Potentiometer	BRN	3386H-1-104	RP-111-100K
R1203	50Ω, .5W, Potentiometer	BRN	3386H-1-500	RP-111-50
R1204	500Ω, .5W, Potentiometer	BRN	3386H-1-501	RP-111-500
R1205	5KΩ, .5W, Potentiometer	BRN	3386H-1-502	RP-111-5K
R1206	150KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-150K
R1207	2.21KΩ, 0.1%, 10W, MTF	TRW	MAR-5-1%-T10	R-241-2.21K
R1208	10MΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10M
R1209	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R1210	15KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1-1%	R-88-15K
R1211	24.3KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-24.3K
R1212	500Ω, .10W, 0.1%, MTF	TRW	MAR 5 T-10; 0.1%	R-241-500
R1213	68.1KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-68.1K
R1214	68,1KΩ, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-68.1K

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
R1215	500Ω, .10W, 0.1%, MTF	TRW	MAR 5, T-10; 0.1%	R-241-500
R1216*	219.7KΩ	K-I	...	R-254
R1217*	19.93KΩ	K-I	...	R-254
R1218*	1954Ω	K-I	...	R-254
R1219*	2MΩ	K-I	...	R-254
R1220*	2MΩ	K-I	...	R-254
R1221	3.3KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-3.3K
R1222	NOT USED	...	...	...
R1223	47Ω, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-47
R1224	1MΩ, 1%, 1/4W, Comp	A-B	CB-106-10%	R-76-1M

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
U1201	Op-Amp, 8-Pin DIP	NAT	LM301AN	IC-24
U1202	Op-Amp, 8-Pin DIP	NAT	LM301AN	IC-24
U1203	Op-Amp, JFET Input, Case TO-99.	NAT	LF356H	IC-152

VOLTAGE RECTIFIERS (VR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1200" SERIES (Schematic 27944D) (PC-414)			
VR1201	Zener, 9.1V	ITT	1N757A	DZ-38
VR1202	Zener, 9.1V	ITT	1N757A	DZ-38
VR1203	Zener, 9.1V	ITT	1N757A	DZ-38
VR1204	Zener, 12V, 400mW	DIC	1N963B	DZ-54

MODEL 1744 OHMS OPTION (PC-408)

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
C1101	100pF, 1000V, CerD	.CLB	DD-101	C-64-100P
C1102	1500pF, 500V, Poly	.CLB	CPR-1000J	C-138-1500P

DIODES (D)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
CR1101	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28
CR1102	Rectifier, 1A, 800V.	.MOT	IN4006	RF-38
CR1103	Rectifier, 1A, 800V.	.MOT	IN4006	RF-38
CR1104	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28
CR1105	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28
CR1106	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28
CR1107	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28
CR1108	Rectifier, 75mA, 75V	.T-I	IN4148	RF-28

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
J1101	Connector.	.MOL	09-62-3151	CS-337-10

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
Q1101	FET, Case TO-18 (Selected TG-88)	.K-I	...	28250A
Q1102	FET, Case TO-18.	.INT	ITS3538	TG-88
Q1103	FET, Case TO-18.	.INT	ITS3538	TG-88
Q1104	N-Chan JFET, Case.	.INT	ITE4392	TG-77
Q1105	NPN, Case TO-106	.F-I	2N3565	TG-39
Q1106	NPN, Case TO-106	.F-I	2N3565	TG-39

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
Q1108	NPN, Case TO-5	RCA	2N3439	TG-93
Q1108	NPN, Case TO-106	F-I	2N3565	TG-39
Q1109	NPN, Case TO-106	F-I	2N3565	TG-39
Q1110	NPN, Case TO-106 (Selected TG-39)	F-I	2N3565	28234A
Q1111	NPN, Case TO-106 (Selected TG-39)	F-I	2N3565	28234A

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
R1101	3.28KΩ	K-I	SPECIAL	R-240-3.28K
R1102	50Ω, .5W, Potentiometer	BRN	2286-H-1-500	RP-111-50
R1103	5KΩ, .5W, Potentiometer	BRN	3386-H-1-102	RP-111-5K
R1104	500KΩ, .5W, Potentiometer	BRN	3386-H-1-504	RP-111-500K
R1105	335.3KΩ, MTF	TRW	MAR-5-0.1%, T-10	R-241-335.3K
R1106	1KΩ, .5W, Potentiometer	BRN	3386-H-1-502	RP-111-5K
R1107	33.2MΩ, Film Res	CAD	MG 721; 0.25%	R-242-33.2M
R1108	1MΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-1M
R1109	100KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-100K
R1110	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R1111	100KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-100K
R1112	47KΩ, 10%, 2W, Comp	A-B	HB, 1%	R-3-47K
R1113	22KΩ, 10%, 2W, Comp	A-B	HB, 1%	R-3-22K
R1114	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R1115	12KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-12K
R1116	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R1117	1KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-1K
R1118	10KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-10K
R1119	15KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-15K
R1120	150KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-150K
R1121	390Ω, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-390
R1122	390Ω, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-390
R1123	150KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-248-150K
R1124	1M, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-1M
R1125	1M, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-1M

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
U1101	Op-Amp, 8-Pin DIP	NAT	LM308N	IC-99
U1102	Op-Amp, Case TO-5	NAT	LH0042CH	IC-132

VOLTAGE RECTIFIERS (VR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 27941C) (PC-408)			
VR1101	Zener, 3.3V, 400mW.	DIC	1N746A	DZ-40

MODEL 1745 CURRENT OPTION
"1000" SERIES (Schematic 27940C)
(PC-409)

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
C1001	47pF, 1000V, CerD. . . . . .CLB		DD-470	C-64-47P

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
CR1001	Bridge Rectifier, 4-diode 50V, 5A EDI		PE05	RF-48

FUSES (F)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
F1001	Fuse, 3AG,250V, 4A . . . . . .L-F		312004	FU-39

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
J1001	Connector. . . . . .MOL		09-62-3051	CS-337-5
J1002	Connector. . . . . .MOL		09-62-3051	CS-337-10

RESISTORS (R)

Circuit Desig.	Descriptions	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
R1001	1KΩ, .05W, Potentiometer.	BRN	3386H-1-102	RP-111-1K
R1002	100Ω, .05, Potentiometer.	BRN	3386H-1-102	RP-111-100
R1003	10Ω, .05W, Potentiometer.	BRN	2286H-1-100	RP-111-10
R1004	10KΩ, .05W, Potentiometer	BRN	3386H-1-103	RP-111-10K
R1005	1KΩ, .05W, Potentiometer.	BRN	3386H-1-102	RP-111-1K
R1006	100Ω, .05W, Potentiometer	BRN	3386H-1-101	RP-111-100
R1007	20Ω, .05W, Potentiometer	BRN	3386H-1-200	RP-111-20
R1008	0.1011Ω, 7.5W, 0.1%, MTF.	K-I	SPECIAL	R-262-.1011
R1009	105KΩ, 1W, 0.1%, MTF	K-I	SPECIAL	R-251-105K
R1010	0.915Ω, 5W, 0.1%, MTF	K-I	SPECIAL	R-232-.915
R1011	9.15Ω, .5W, 0.1%, MFF	K-I	SPECIAL	R-252-9.15
R1012	10Ω, 1%, 1/8W, MTF.	IRC	CMF 1/10; T-1, 1%	R-88-10
R1013	4.99KΩ, 1%, 1/8W, MTF	IRC	CMF 1/10; T-1, 1%	R-88-4.99K
R1014	900Ω, 1W, 0.1%, MTF	K-I	SPECIAL	R-249-900
R1015	49.9Ω, 1%, 1/8W, MTF.	DLE	CMF 1/10; T-1, 1%	R-88-49.9
R1016	499Ω, 1%, 1/8W, MTF	DLE	CMF 1/10; T-1, 1%	R-88-499
R1017	4.7KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-4.7K
R1018	91.5Ω, 5W, 0.1%, MTF.	K-I	SPECIAL	R-252-91.5
R1019	9KΩ, 7W, 0.1%, MTF	K-I	SPECIAL	R-250-9K
R1020	3.9KΩ, 5%, 1/4W, Comp	MEP	CR25, 5%	R-76-3.9K

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27940C) (PC-409)			
U1001	Op-Amp, Case TO-99.	NAT	LM308H	IC-67

TABLE 7-2.
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
C001	27936F	B4	412	C5
C002	27936F	B4	412	C5
C003	27936F	J6	412	C5
C004	27936F	K7	412	C5
C005	27936F	L5	412	C4
C006	27936F	Q6	412	D5
C007	27936F	Q6	412	D5
C008	27936F	Q5	412	D5
C009	27936F	P5	412	D5
C010	27936F	P6	412	D5
C011	27936F	N5	412	E5
C101	27936F	K8	412	C5
C102	27936F	J8	412	C4
C103	27936F	B3	412	C4
C104	27936F	I2	412	C4
C105	27936F	I2	412	C4
C106	27936F	J3	412	C4
C107	27936F	L3	412	C4
C108	27936F	L3	412	C4
C109	27936F	I2	412	C4
C110	27936F	K4	412	C4
C111	27936F	L3	412	C5
C112	27936F	L2	412	D4
C113	27936F	L1	412	D4
C114	27936F	L1	412	D4
C115	27936F	K1	412	D4
C201	27936F	D7	412	E4
C202	27936F	D8	412	E4
C203	27936F	F7	412	E4
C204	27936F	F7	412	E4
C205	27936F	E7	412	E4
C206	27936F	C7	412	E3
C207	27936F	E6	412	E3
C208	27936F	D4	412	E3
C209	27936F	E5	412	E4
C210	27936F	C6	412	E3
C211	27936F	C3	412	F5
C212	27936F	C3	412	D3
C213	27936F	E7	412	E4
C401	27938D	C4	412	B3
C402	27938D	C4	412	B3
C403	27938D	E4	412	B3
C404	27938D	C2	412	B3
C405	27938D	E3	412	B3
C406	27938D	E2	412	B4
C407	27938D	D2	412	B3
C408	27938D	E4	412	C3
C409	27938D	E4	412	C3
C410	27938D	F3	412	C5
C411	27938D	F3	412	C5
C501	27935E	G5	412	F5
C502	27935E	H5	412	F3
C503	27935E	H5	412	G2
C601	27937D	D3	412	C2
C602	27937D	D2	412	C2
C603	27937D	G3	412	C2
C604	27937D	G3	412	C2
C605	27937D	F4	412	C2
C606	27937D	E4	412	D2
C607	27937D	E2	412	D2
C608	27937D	D4	412	D2
C609	27937D	D3	412	D2
C610	27937D	C4	412	D2
C611	27937D	C4	412	E2
C701	28209E	M6	421	F2
C702	28209E	M6	421	F2
C703	28209E	I2	421	E2
C704	28209E	M6	421	E2
C705	28209E	G3	421	G4
C706	28209E	N5	421	G5
C707	28209E	N6	421	G5
C708	28209E	N3	421	F5
C709	28209E	K3	421	F5
C710	28209E	M2	421	E5
C801	27929D	B3	410	F2
C802	27939D	B3	410	F2
C901	27935E	M3	412	C3
C902	27935E	M3	412	C3
C903	27935E	L3	412	C3
C904	27935E	L3	412	D3
CR001	27936F	K7	412	C5
CR002	27936F	K7	412	C5
CR003	27936F	Q7	412	C5

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
CR101	27936F	K2	412	D4
CR102	27936F	K2	412	D4
CR201	27936F	I7	412	D4
CR202	27936F	H6	412	D4
CR203	27936F	G6	412	D4
CR204	27936F	G4	412	D4
CR205	27946F	F5	412	D5
*CR206	27936F	B6	412	E4
CR207	27936F	E8	412	E4
CR208	27936F	H7	412	E4
CR209	27936F	H7	412	E4
CR210	27936F	F3	412	E4
CR211	27936F	C6	412	E4
CR212	27936F	F6	412	E4
CR213	27936F	C6	412	E3
CR214	27936F	B7	412	D4
CR215	27936F	H7	412	D4
CR216	27936F	H7	412	D4
*CR217	27936F	B6	412	D3
CR218	27936F	I8	412	E3
CR219	27936F	G8	412	E4
CR220	27936F	G8	412	E4
CR401	27938D	B2	412	B2
CR402	27938D	B3	412	B2
CR501	27935E	G6	412	F4
CR502	---	--	--	--
CR503	27935E	B4	412	F2
CR504	27935E	B4	412	G2
CR601	27937D	C4	412	D2
CR602	27937D	C4	412	D2
CR701	28209E	J3	421	G4
CR702	28209E	J3	421	G4
CR703	28209E	J3	421	G4
CR704	28209E	J2	421	G4
CR705	28209E	I7	421	E3
CR706	28209E	H6	421	E3
CR707	28209E	E6	421	F4
CR708	28209E	G7	421	F4
CR709	28209E	C7	421	E4
CR710	28209E	E6	421	E4
CR711	28209E	N6	421	G5
CR712	28209E	K3	421	F5
CR713	28209E	G2	421	F4
CR714	28209E	C2	421	G4
CR801	27939D	B3	410	E2
DS801	27939D	E5	410	C2
DS802	27939D	F5	410	D2
DS803	27939D	G5	410	D2
DS804	27939D	H5	410	D2
DS805	27939D	H4	410	E2
DS806	27939D	G4	410	E2
DS807	27939D	B4	410	C2
DS808	27939D	C3	410	D3
DS809	27939D	C3	410	D3
DS810	27939D	D3	410	D2
DS811	27939D	D3	410	D3
DS812	27939D	C3	410	E3
DS813	27939D	D3	410	E2
DS814	27939D	D3	410	E3
DS815	27939D	C3	410	F3
J201	27936F	Q1	412	E5
J301	---	--	---	--
J302	27935E	A2	---	--
J303	27935E	A2	---	--
J304	27935E	A3	---	--
J601	27937D	D5	410	G5
J602	27937D	F1	410	G5
J603	27937D	D4	410	G5
J701	---	--	---	--
J702	28209E	H1	421	E4
J703	28209E	C7	421	G5
J704	28209E	A1	421	F5
J705	28209E	B7	421	E5
P801	27939D	A1	410	E2
K501	27935E	H5	412	F3
K502	27935E	G4	412	F2
K503	27935E	B3	412	F2

* Resistor Networks may have several Schematic locations:

CR206 - 2 Resistors (A-B) B6 & B7
CR217 - 2 Resistors (A-B) B6 & B7

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
P301	27935E	J2	---	--
P401	27938D	E5	412	F5
P402	27938D	G1	412	B5
P403	27938D	D1	412	F5
P404	27938D	B1	412	B2
P405	27938D	A4	(REAR PANEL)	
P501	27935E	I4	412	F4
P502	27935E	I5	412	F3
P503	27935E	J5	412	F4
P504	27935E	D6	412	F5
P505	27935E	D4	412	F4
P601	27937D	B5	412	E2
P602	---	--	---	--
P603	27937D	D5	412	E2
P701	28209E	H2	421	E3
P901	---	--	---	--
P902	27935E	F8	412	D3
P903	27935E	D8	412	C3
P904	27935E	C8	412	D3
P905	27935E	C8	412	D3
*Q001	27936F	J6	412	C5
Q002	27936F	M5	412	D5
Q003	27936F	Q6	412	D5
Q101	27936F	I7	412	B4
*Q102	27936F	J7	412	C4
Q103	27936F	K3	412	C4
Q104	27936F	I3	412	C4
*Q105	27936F	J6	412	C4
Q106	27936F	K3	412	C4
Q107	27936F	L1	412	C4
Q108	27936F	M2	412	C4
Q109	27936F	L1	412	C4
Q110	27936F	K2	412	D4
Q111	27936F	M1	412	D4
Q112	27936F	J2	412	D4
Q113	27936F	K1	412	D4
Q114	27936F	N1	412	D5
Q201	27936F	I4	412	C4
Q202	27936F	G5	412	D4
Q203	27936F	G5	412	D4
Q204	27936F	I5	412	D4
Q205	27936F	B7	412	D4
Q206	27936F	B7	412	D4
Q207	27936F	B6	412	D3
Q208	27936F	G4	412	D4
Q209	27936F	E4	412	E4
Q210	27936F	E7	412	E4
Q211	27936F	E5	412	E4
Q212	27936F	E5	412	E4
Q213	27936F	C5	412	E4
Q214	27936F	D5	412	E3
Q215	27936F	D5	412	E4
Q216	27936F	C6	412	E3
Q401	27938D	D4	412	B2
Q402	27938D	D2	412	B2
Q403	27938D	D3	412	B2
Q501	27935E	G6	412	F4
Q601	---	--	---	--
Q602	27937D	F3	412	C2
Q603	27937D	E3	412	D3
*Q604	27937D	D3	412	D2
Q701	28209E	J2	421	G3
Q702	28209E	G4	421	F4
Q703	28209E	G3	421	F4
Q704	28209E	I6	421	E3
Q705	28209E	H7	421	E3
Q706	28209E	F2	421	F4
Q707	28209E	G7	421	F4
Q708	28209E	G2	421	F4
Q709	28209E	D2	421	G4
Q710	28209E	E2	421	G4
Q711	28209E	I4	421	F4
Q712	28209E	C2	421	G3
Q713	28209E	A2	421	F4
Q714	28209E	A2	421	F4

* Resistor Networks may have several Schematic locations:

Q001 - 2 Resistors (A-B) J6 & K6
Q002 - 2 Resistors (A-B) J7 &
Q105 - 2 Resistors (A-B) J6 & J7
Q604 - 2 Resistors (A-B) D3 & D4

TABLE 7-2 (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
Q715	28209E	B2	421	F4
Q716	28209E	F2	421	F5
Q717	28209E	H1	421	F4
Q718	28209E	N6	421	G5
Q719	28209E	K3	421	F5
Q720	28209E	K6	421	F5
Q721	28209E	L1	421	F5
Q722	28209E	K1	421	E5
Q801	27939D	B6	410	C3
Q802	27939D	B5	410	D2
Q803	27939D	B4	410	E2
Q804	27939D	B4	410	E2
Q805	27939D	B5	410	E2
Q806	27939D	B6	410	E2
Q807	27939D	B5	410	E2
Q808	27939D	B5	410	E2
Q809	27939D	B5	410	E3
Q810	27939D	D2	410	E2
Q811	27939D	D2	410	F1
Q812	27939D	D2	410	F1
Q813	27939D	D1	410	F1
Q814	27939D	D1	410	F1
Q815	27939D	D2	410	F2
R001	27936F	L8	412	C5
*R002	27936F	K6	412	C5
R003	27936F	M5	412	D5
R004	27936F	N5	412	D5
R005	27936F	N5	412	D5
R006	27936F	Q7	412	D5
R007	27936F	Q7	412	D5
R008	27936F	N6	412	D5
R009	27936F	Q7	412	D5
R010	27936F	P6	412	D5
R011	27936F	P7	412	D5
R012	27936F	P8	412	D5
R013	27936F	P5	412	D5
R014	27936F	P6	412	D5
R101	27936F	K7	412	B5
R102	27936F	K7	412	B5
R103	27936F	I8	412	C4
R105	27936F	I7	412	B4
R105	27936F	I6	412	C3
R106	27936F	I2	412	C4
R107	27936F	I3	412	C4
R108	27936F	H2	412	C4
*R109	27936F	J2	412	C3
*R110	27936F	L2	412	D4
R111	27936F	L5	412	D5
R112	27936F	M2	412	D5
R113	27936F	N1	412	D5
R201	27936F	H3	412	C4
R202	27936F	G2	412	C4
R203	27936F	H3	412	C4
R204	27936F	H4	412	C4
R205	27936F	F3	412	C4
R206	27936F	G2	412	C4
R207	27936F	F2	412	C4
R208	27936F	E3	412	D4
R209	27936F	F6	412	D4
*R210	27936F	G6	412	D4
R211	27936F	G3	412	D4
R212	27936F	D3	412	D4
R213	27936F	D3	412	D4
*R214	27936F	I7	412	D3
*R215	27936F	E8	412	D4
R216	27936F	I6	412	D4
R217	27936F	F5	412	D4
*R218	27936F	C8	412	D3
R219	27936F	I6	412	D4
R220	27936F	H4	412	D3
R221	27936F	D8	412	E4
R222	27936F	G7	412	E4
R223	27936F	H3	412	E4
*R224	27936F	E6	412	E4
R225	27936F	B7	412	E3

* Resistor Networks may have several Schematic locations:

R002 - 6 Resistors (A-F) K5, K6, L6
R109 - 4 Resistors (A-D) J2, J7, J8
R110 - 4 Resistors (A-D) L1, L2
R210 - 8 Resistors (A-H) E2, E4, F5, G5
R214 - 5 Resistors (A-E) I4, I5, I7
R215 - 8 Resistors (A-H) E8, F8, G8, I8
R218 - 5 Resistors (A-E) C8, A6, A7
R224 - 6 Resistors (A-F) E5, E6, F3, G4

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
R226	27936F	C5	412	E4
R227	27936F	C5	412	E4
R228	27936F	C4	412	E3
R229	27936F	H8	412	D3
*R230	27936F	C6	412	E4
R231	27936F	Q4	412	E5
R232	27936F	F8	412	E5
R233	27936F	H8	412	E5
R234	27936F	B6	412	D3
R235	27936F	B8	412	E4
R401	27938D	C2	412	B5
R402	27938D	C3	412	B5
R403	27938D	E3	412	C5
R404	27938D	C4	412	B3
R405	27938D	D2	412	B2
R406	27938D	D2	412	B2
R407	27938D	C3	412	B2
R408	27938D	B5	412	F5
R501	---	--	---	--
R502	---	--	---	--
R503	27935E	F5	412	F5
R504	27935E	G5	412	F5
R505	27935E	F6	412	F5
R506	27935E	G6	412	F4
R507	27935E	G7	412	F4
R508	27935E	G6	412	F4
R509	27935E	L3	412	F4
R510	27935E	K3	412	F3
R511	27935E	K3	412	F4
R512	27935E	F7	412	F3
R513	27935E	F7	412	F3
R514	---	--	---	--
R515	27935E	G5	412	F4
R516	27935E	G5	412	F3
R517	27935E	K2	412	F3
R518	27935E	K2	412	F3
R519	27935E	K2	412	F3
R520	27935E	J1	412	F2
R521	27935E	C2	412	F2
R522	27935E	G4	412	G2
R523	27935E	H4	(FUNCTION SWITCH)	
R524	27935E	H4		
R525	27935E	C3	(FUNCTION SWITCH)	

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
R601	27937D	C2	412	C2
R602	27937D	D3	412	C2
R603	27937D	C3	412	C2
R604	27937D	H3	412	C2
R605	27937D	G5	412	C2
R606	27937D	G3	412	C2
R607	27939D	F3	412	C2
R608	---	--	--	---
R609	27937D	E4	412	C2
R610	27937D	E2	412	D2
R611	27939D	E2	412	D2
R612	27937D	E4	412	D2
R613	27937D	F3	412	D2
R614	27937D	E4	412	D2
R615	27937D	H4	412	D2
R616	27937D	H4	412	D2
R617	27937D	E4	412	D2
R618	27937D	D3	412	D2
R619	27937D	C3	412	E2
R620	27937D	C3	412	E2
R621	27937D	B3	412	E2
*R622	27937D	G6	412	E2
R623	27937D	D4	410	F2
R624	27937D	E5	410	F4
R701	28209E	H3	421	F2
R702	28209E	I2	421	G4
R703	28209E	J3	421	G4
R704	28209E	G3	421	F3
R705	28209E	G4	421	F3
R706	28209E	I6	421	E3
R707	28209E	B6	421	E3
R708	28209E	H6	421	E3
R709	28209E	J8	421	G4
R710	28209E	J8	421	G4
R711	28209E	K7	421	G4
R712	28209E	E2	421	G4
R713	28209E	D2	421	G4
R714	28209E	E2	421	G4
R715	28209E	I4	421	G4

* Resistor Networks may have several Schematic locations:

R230 - 6 Resistors (A-F) C5, C6, D6
R622 - 14 Resistors (A-P) B6, C6, D6, E6, F6

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
R716	28209E	A6	421	G4
R717	28209E	A6	421	G4
R718	28209E	H7	421	G4
R719	28209E	C2	421	G4
R720	28209E	A2	421	F4
R721	28209E	A2	421	F4
R722	28209E	F6	421	F4
R723	28209E	B2	421	F4
R724	28209E	B6	421	F4
R725	28209E	B6	421	F4
R726	28209E	F2	421	F4
R727	28209E	F2	421	F4
R728	28209E	F3	421	F4
R729	28209E	I6	421	F4
R230	28209E	G4	421	F4
R731	28209E	H2	421	F4
R732	28009E	G3	421	F4
R733	28209E	G2	421	F4
R734	28209E	G7	421	F4
R735	28209E	J8	421	F4
R736	28209E	J1	421	E4
R737	28209E	J5	421	E4
R738	28209E	J3	421	E4
R739	28209E	C6	421	E4
R740	28209E	D6	421	E4
R741	28209E	I7	421	E4
R742	28209E	H7	421	E4
R743	28209E	C6	421	E4
R744	28209E	D3	421	E4
R745	28209E	H2	421	G4
R746	28209E	F2	421	F4
R747	28209E	N5	421	G5
R748	28209E	N6	421	G5
R749	28209E	M6	421	G5
R750	28209E	N6	421	G5
R751	28209E	K5	421	G5
R752	28209E	L3	421	F5
R753	28209E	K3	421	F5
R754	28209E	J2	421	F5
R755	28209E	L3	421	F5
R756	28209E	M3	421	F5
R757	28209E	K5	421	F5
R758	282029	L2	421	F5
R759	28209E	N2	421	E5
R760	28209E	N2	421	E5
R761	28209E	M2	421	E5
R762	28209E	L1	421	E5
R763	28209E	L1	421	E5
R764	28209E	K1	421	E5
R765	28209E	C3	421	F3
R801	27939D	C6	410	D2
*R802	27939D	C6	410	D2
R803	27939D	B3	410	E2
R804	27939D	B6	410	E3
R805	27939D	D3	410	F3
*R806	27939D	C1	410	F2
R807	27939D	E5	410	C2
R808	27939D	B3	410	E2
R809	27939D	A2	410	F3
R810	27939D	B1	410	F3
R901	27935E	M3	412	C3
R902	27935E	L3	412	C3
R903	27935E	L3	412	C3
R904	27935E	L2	412	D3
S301	27935E	A4	412	G3
S302	27935E	B1	(FUNCTION SWITCH)	
S401	27938D	A2	412	B4
S402	27938D	A3	412	B5
T401	27938D	B1	(REAR PANEL)	
*U001	27936F	L7	412	C5
*U002	27936F	M5	412	C5
*U003	27936F	M6	412	C5
U004	27936F	N7	412	D5
U005	27936F	Q5	412	D5

* Resistor Networks may have several Schematic locations:

R802 - 8 Resistors (A-H) C5, D5, E4
R806 - 12 Resistors (A-M) C1, C2
U001 - 5 Resistors (A-E) L6, L7, M8
U002 - 2 Resistors (A-B) M5
U003 - 2 Resistors (A-B) M5, M7

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
U101	27936F	I2	412	C4
U102	27936F	L4	412	D4
U103	27936F	N1	412	E5
U201	27936F	F7	412	D4
U202	27936F	F4	412	D4
U601	27937D	G3	412	C2
U602	27937D	E3	412	D2
U701	28209E	I5	421	G2
U702	28209E	J4	421	F2
U703	28209E	I3	421	F2
*U704	28209E	K7	421	G3
*U705	28209E	H6	421	F3
*U706	28209E	C3	421	F3
*U707	28209E	E4	421	E3
U708	28209E	J7	421	G3
*U709	28209E	E3	421	F3
*U710	28209E	A3	421	F3
*U711	28209E	D4	421	E3
*U712	28209E	F4	421	F4
U713	28209E	L6	421	G5
U714	28209E	N4	421	F5
U715	28209E	L4	421	F5
U716	28209E	N2	421	E5
U801	27939D	B1	410	F3
U901	27935E	M3	412	C3
VR001	27936F	Q8	412	D5
VR101	27936F	K7	412	C5
VR102	27936F	J8	412	C4
VR201	27936F	G2	412	C4
VR202	27936F	F2	412	C4
VR203	27936F	D8	412	E4
VR401	27938D	E2	412	B4
VR402	27938D	E4	412	B3
VR403	27938D	D2	412	B2
VR404	27938D	F3	412	C5
VR405	27938D	D4	412	C3
VR406	27938D	D4	412	C3
VR701	28209E	G3	421	G4
W201	27936F	E2	412	C4
W401	27938D	E2	412	B4
W402	27938D	F4	412	C3
W403	27938D	F3	412	C3
C1001	27902E	N7	415	C3
C1002	27902E	C2	415	B5
C1003	27902E	C2	415	C5
C1004	27902E	C3	415	E5
C1005	27902E	C2	415	E5
C1006	27902E	C2	415	E5
C1007	27902E	A3	415	D5
C1008	27902E	A4	415	D5
C1009	27902E	G1	415	B5
C1010	27902E	A6	415	B5
C1011	27902E	B6	415	C5
C1012	27902E	A6	415	C5
C1013	27902E	B6	415	D5
C1014	27902E	C3	415	D5
C1015	27902E	C2	415	D5
C1016	27902E	A8	415	B6
C1017	27902E	B1	415	D6
C1018	27902E	B1	415	D6
C1101	28019E	G7	416	D4
C1102	28019E	G7	416	D4
C1103	28019E	H3	416	C5
C1104	28019E	G7	416	D4
C1105	28019E	G7	416	D5
C1106	28019E	A5	416	B5
C1107	28019E	A5	416	B5
CR1001	27902E	B2	415	E5
CR1002	27902E	A4	415	D5
CR1101	28019E	H3	416	C5
J1001	27902E	A1	415	E2
J1002	27902E	A2	415	B6
J1003	---	--	---	--

* Resistor Networks may have several Schematic locations:

U704 - 6 Resistors (A-F) F8, I7, K7, J7
U705 - 2 Resistors (A-B) A5, H6
U706 - 3 Resistors (A-C) C3, C4, D4
U707 - 4 Resistors (A-D) C4, D4, E4
U709 - 6 Resistors (A-F) A3, B3, C3, I6
U710 - 3 Resistors (A-C) A3, B3
U711 - 6 Resistors (A-F) B6, D3, C5, H6
U712 - 6 Resistors (A-F) F3, F4, I3

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
J1101	---	---	--	---
J1102	---	---	--	---
J1103	---	---	--	---
J1104	28019E	I7	416	B4
J1105	28019E	B8	416	B5
P1001	---	---	--	---
P1002	---	---	--	---
P1003	---	---	--	---
P1004	27902E	N4	415	B4
P1005	27902E	B8	415	B5
P1006	27902E	C7	(CARD EDGE)	
P1101	28019E	B1	(CARD EDGE)	
Q1001	27902E	F7	415	B3
Q1002	27902E	G7	415	B3
Q1003	27902E	E7	415	B3
Q1004	27902E	C7	415	B3
Q1005	27902E	D7	415	B3
Q1006	27902E	N7	415	B3
Q1007	27902E	M7	415	B3
Q1008	27902E	M7	415	C3
Q1009	27902E	M7	415	C3
Q1010	27902E	L7	415	C3
Q1011	27902E	L7	415	C3
Q1012	27902E	L7	415	C3
Q1013	27902E	K7	415	C3
Q1014	27902E	K7	415	C3
Q1015	27902E	K7	415	C3
Q1016	27902E	K7	415	C3
Q1017	27902E	J7	415	D3
Q1018	27902E	J7	415	C3
Q1019	27902E	I7	415	C3
Q1020	27902E	J7	415	D3
Q1021	27902E	I7	415	D3
Q1022	27902E	H7	415	D3
Q1023	27902E	H7	415	D3
Q1024	27902E	H7	415	D3
Q1025	27902E	H7	415	D3
Q1026	27902E	G7	415	D3
Q1027	27902E	G7	415	D3
Q1028	27902E	F7	415	D3
Q1029	27902E	F7	415	D3
Q1030	27902E	E7	415	D3
Q1031	27902E	E7	415	D3
Q1032	27902E	E7	415	E3
Q1033	27902E	D7	415	E3
Q1034	27902E	B6	415	B5
Q1035	27902E	B7	415	C6
Q1036	27902E	A7	415	C6
Q1037	27902E	B7	415	D6
Q1101	28019E	I5	416	B3
*R1001	27902E	F6	415	B4
*R1002	27902E	M6	415	C4
*R1003	27902E	K6	415	C4
*R1004	27902E	K6	415	D4
*R1005	27902E	F6	415	D4
R1006	27902E	G1	415	D5
R1007	27902E	A4	415	D5
R1008	27902E	B2	415	E5
R1009	27902E	B6	415	C5
R1010	27902E	A6	415	C5
R1011	27902E	A7	415	C5
R1012	27902E	B6	415	C5
R1013	27902E	B7	415	C5
R1014	27902E	B7	415	C6
R1015	27902E	A7	415	C6
R1016	27902E	B1	415	D6
R1101	28019E	I5	416	B4
*R1102	28019E	N6	416	B4
*R1103	28019E	N3	416	C4
*R1104	28019E	G4	416	C4
*R1105	28019E	F4	416	C5
R1106	28019E	B5	416	B5
R1107	28019E	A6	416	B5

* Resistor Networks may have several Schematic locations:

R1001 - 7 Resistors (A-G) D6, F6, G6
R1002 - 7 Resistors (A-G) K6, L6, M6
R1003 - 7 Resistors (A-G) I6, J6
R1004 - 7 Resistors (A-G) G6, H6, I6
R1005 - 7 Resistors (A-G) C6, D6, E6, F6
R1102 - 13 Resistors((A-N) N4, N5, N6
R1103 - 13 Resistors (A-N) N1, N2, N3
R1104 - 13 Resistors (A-N) F1, F2, G1, G2
R1105 - 13 Resistors (A-N) F3, F4, F5

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
T1001	27902E		415	E4
*U1001	27902E	M6	415	B4
*U1002	27902E	L6	415	C4
*U1003	27902E	K6	415	C4
*U1004	27902E	I6	415	D4
*U1005	27902E	H6	415	D4
*U1006	27902E	G6	415	D4
*U1007	27902E	E6	415	B4
*U1008	27902E	L1	415	C4
*U1009	27902E	K1	415	C4
*U1010	27902E	I1	415	D4
*U1011	27902E	H1	415	D4
*U1012	27902E	E7	415	D4
*U1013	27902E	N3	415	B5
*U1014	27902E	A5	415	C5
*U1015	27902E	C5	415	C5
*U1016	27902E	A5	415	D5
U1017	27902E	A3	415	D5
U1018	27902E	A7	415	B5
U1019	27902E	B7	415	C5
U1020	27902E	A7	415	C5
U1021	27902E	B7	415	D5
U1101	28019E	M4	416	C4
U1102	28019E	J4	416	D4
U1103	28019E	C3	416	B4
U1104	28019E	H3	416	C4
U1105	28019E	C3	416	D4
U1106	28019E	B4	416	B5
U1107	28019E	E7	416	C5
U1108	28019E	D5	416	D5
U1109	28019E	I4	416	C5
U1110	28019E	E7	416	C5
U1111	28019E	B6	416	D5
BT401	26758C	C3	404	D4
BT402	26758C	C4	404	D3
BT403	---	--	---	--
F401	26758C	C2	404	B4
F402	26758C	D4	404	B3
F403	26758C	E2	404	B3
CR401	26758C	B2	404	B2
CR402	26758C	B2	404	B2
CR403	26758C	C2	404	B2
CR404	26758C	B4	404	B2
CR405	26758C	B5	404	B2
CR406	26758C	C5	404	B2
CR407	26758C	D2	404	C2
CR408	26758C	D2	404	B2
CR409	26758C	E1	404	B2
CR410	26758C	D2	404	C2
J401	26758C	A1	404	A5
J402	26758C	B1	404	A2
Q401	26758C	C2	404	B2
Q402	26758C	C5	404	B2
Q403	26758C	E1	404	C2
Q404	26758C	E4	404	C2
Q405	26758C	F4	404	B2
R401	26758C	B2	404	B2
R402	26758C	B3	404	B2
R403	26758C	B4	404	C2
R404	26758C	B5	404	B2
R405	26758C	D1	404	C2
R406	26758C	D2	404	C2
R407	26758C	E4	404	C2
R408	26758C	F2	404	C2
R409	26758C	D5	404	C2
R410	26758C	E5	404	C2
R411	26758C	D3	404	C2
R412	26758C	D4	404	B3
R413	26758C	D1	404	B2
R414	26758C	E3	404	C2
U401	26758C	E4	404	C2

* Resistor Networks may have several Schematic locations:

U1001-- 4 Resistors (A-D) L6, M6
U1002 - 4 Resistors (A-D) K6, L6
U1003 - 4 Resistors (A-D) J6, K6
U1004 - 4 Resistors (A-D) I6
U1005 - 4 Resistors (A-D) H6
U1007 - 4 Resistors (A-D) D6, G6
U1008 - 2 Resistors (A-B) L1, M1
U1009 - 2 Resistors (A-B) K1
U1010 - 2 Resistors (A-B) J1
U1011 - 2 Resistors (A-B) H1
U1012 - 4 Resistors (A-D) D7, E7
U1013 - 4 Resistors (A-D) D4, F7
U1014 - 4 Resistors (A-D) C5
U1015 - 2 Resistors (A-B) C5
U1016 - 5 Resistors (A-E) A5, B3, B5

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
C1201	27944D	G2	414	B2
C1202	27944D	H4	414	B2
C1203	27944D	H4	414	B2
C1204	27944D	H3	414	B2
C1205	27944D	F2	414	B2
C1206	27944D	F5	414	B2
C1207	27944D	E5	414	B2
C1208	27944D	G3	414	C3
C1209	27944D	G5	414	C3
C1210	27944D	F3	414	C2
C1211	27944C	F4	414	C2
C1212	27944D	F4	414	C3
C1213	27944D	C3	414	D1
C1214	27944D	C3	414	D1
C1215	27944D	C3	414	D2
C1216	27944D	D3	414	D2
C1217	27944D	D3	414	D2
C1218	27944D	B3	414	D2
C1219	27944D	B4	414	E2
C1220	27944D	A4	414	E2
C1221	27944D	E4	414	E2
C1222	27944D	E3	414	E3
C1223	27944D	E3	414	E3
C1224	27944D	A3	414	F2
C1225	27944D	E2	414	C2
C1226	27944D	C3	414	C2
C1227	27944D	C2	414	C2
C1228	27944D	C3	414	C2
C1229	27944D	B3	414	E2
CR1201	27944D	G5	414	B2
CR1202	27944D	F4	414	C2
CR1203	27944D	F4	414	C2
*CR1204	27944D	D4	414	D2
J1201	27944D	F1	414	C3
J1202	27944D	C1	414	D3
K1201	27944D	C2	414	D2
K1202	27944D	D2	414	D2
K1203	27944D	D2	414	D2
Q1201	27944D	H3	414	B2
Q1202	27944D	H5	414	B2
*Q1203	27944D	G4	414	B2
Q1204	27944D	C4	414	D3

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
R1201	27944D	G2	414	B1
R1202	27944D	F5	414	C1
R1203	27944D	D3	414	C1
R1204	27944D	D3	414	C1
R1205	27944D	C3	414	D1
R1206	27944D	G2	414	B2
R1207	27944D	G2	414	B2
R1208	27944D	G4	414	B1
R1209	27944D	G5	414	B2
R1210	27944D	F5	414	C2
R1211	27944D	F5	414	C2
R1212	27944D	G4	414	C2
R1213	27944D	G4	414	B2
R1214	27944D	G4	414	B3
R1215	27944D	F4	414	C2
R1216	27944D	C3	414	D2
R1217	27944D	D3	414	D2
R1218	27944D	D3	414	D2
R1219	27944D	B3	414	E2
R1220	27944D	B3	414	E2
R1221	27944D	E3	414	E2
R1222	---	--	---	--
R1223	27944D	E2	414	C2
R1224	27944D	E4	414	E2
U1201	27944D	H4	414	B2
U1202	27944D	E5	414	C2
U1203	27944D	E4	414	E2
VR1201	27944D	D1	414	C2
VR1202	27944D	C1	414	C2
VR1203	27944D	B1	414	C2
VR1204	27944D	E3	414	E2
C1101	27941C	C1	408	D4
C1102	27941C	B4	408	E4

* Resistor Networks may have several Schematic locations:

CR1204 - 2 Resistors (A-B) D4, E4
Q1203 - 2 Resistors (A-B) G4

TABLE 7-2. (CON'T)
ZONE DESIGNATIONS

Cir. Desig.	Sch. No.	Sch. Location	PC No.	Comp. Layout Location
CR1101	27941C	B2	408	D3
CR1102	27941C	B5	408	D3
CR1103	27941C	C5	408	D3
CR1104	27941C	B6	408	D3
CR1105	27941C	C6	408	E3
CR1106	27941C	B5	408	E3
CR1107	27941C	C3	408	F4
CR1108	27941C	C2	408	F4
J1101	27941C	A1	408	E4
Q1101	27941C	D2	408	E3
Q1102	27941C	E2	408	F3
Q1103	27941C	B1	408	D4
Q1104	27941C	B2	408	D4
Q1105	27941C	C2	408	D4
Q1106	27941C	B5	408	E4
Q1107	27941C	C5	408	E4
Q1108	27941C	D5	408	E4
Q1109	27941C	D5	408	E4
Q1110	27941C	C4	408	E4
Q1111	27941C	B4	408	E4
R1101	27941C	D2	408	D3
R1102	27941C	D2	408	E3
R1103	27941C	D2	408	E3
R1104	27941C	E2	408	E3
R1105	27941C	E2	408	E3
R1106	27941C	E5	408	F3
R1107	27941C	E2	408	E3
R1108	27941C	B1	408	D3
R1109	27941C	B2	408	D3
R1110	27941C	B3	408	D3
R1111	27941C	C2	408	D3
R1112	27941C	A5	408	D3
R1113	27941C	A5	408	D4
R1114	27941C	B6	408	E3
R1115	27941C	C6	408	E3
R1116	27941C	D6	408	E3
R1117	27941C	D6	408	E3
R1118	27941C	B5	408	E3
R1119	27941C	D4	408	E3
R1120	27941C	E6	408	E3
R1121	27941C	E5	408	E3
R1122	27941C	E5	408	E3
R1123	27941C	E4	408	E3
R1124	27941C	C3	408	F4
R1125	27941C	D3	408	F4
U1101	27941C	C1	408	D4
U1102	27941C	D4	408	F4
VR1101	27941C	C6	408	E3
C1001	27940C	C3	409	E3
CR1001	27940C	C3	409	E3
F1001	27940C	D3	409	E2
J1001	27940C	B2	409	C3
J1002	27940C	B1	409	D3
R1001	27940C	C5	409	C2
R1002	27940C	B4	409	C2
R1003	27940C	B3	409	C2
R1004	27940C	B3	409	D2
R1005	27940C	B2	409	D2
R1006	27940C	C1	409	D2
R1007	27940C	C2	409	D2
R1008	27940C	D2	409	D2
R1009	27940C	B6	409	C3
R1010	27940C	C1	409	C2
R1011	27940C	B2	409	D2
R1012	27940C	C2	409	E2
R1013	27940C	B3	409	C3
R1014	27940C	B4	409	C3
R1015	27940C	B1	409	D3
R1016	27940C	B2	409	D3
R1017	27940C	D4	409	E2
R1018	27940C	B3	409	D3
R1019	27940C	B5	409	C3
R1020	27940C	D5	409	D3
U1001	27940C	D4	409	E3

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO._____ SERIAL NO._____ P.O. NO._____ DATE_____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP_____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.).

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

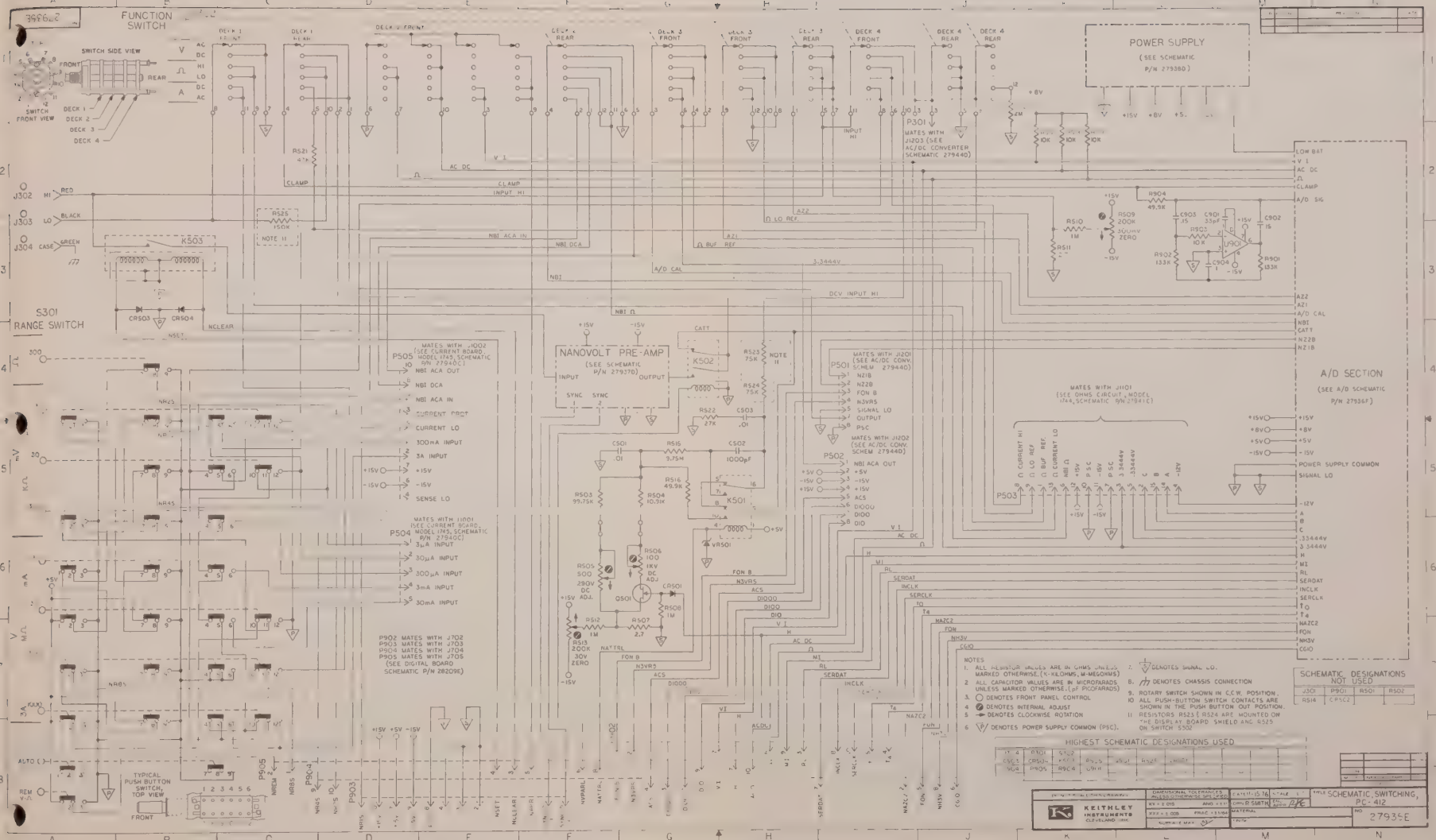
_____

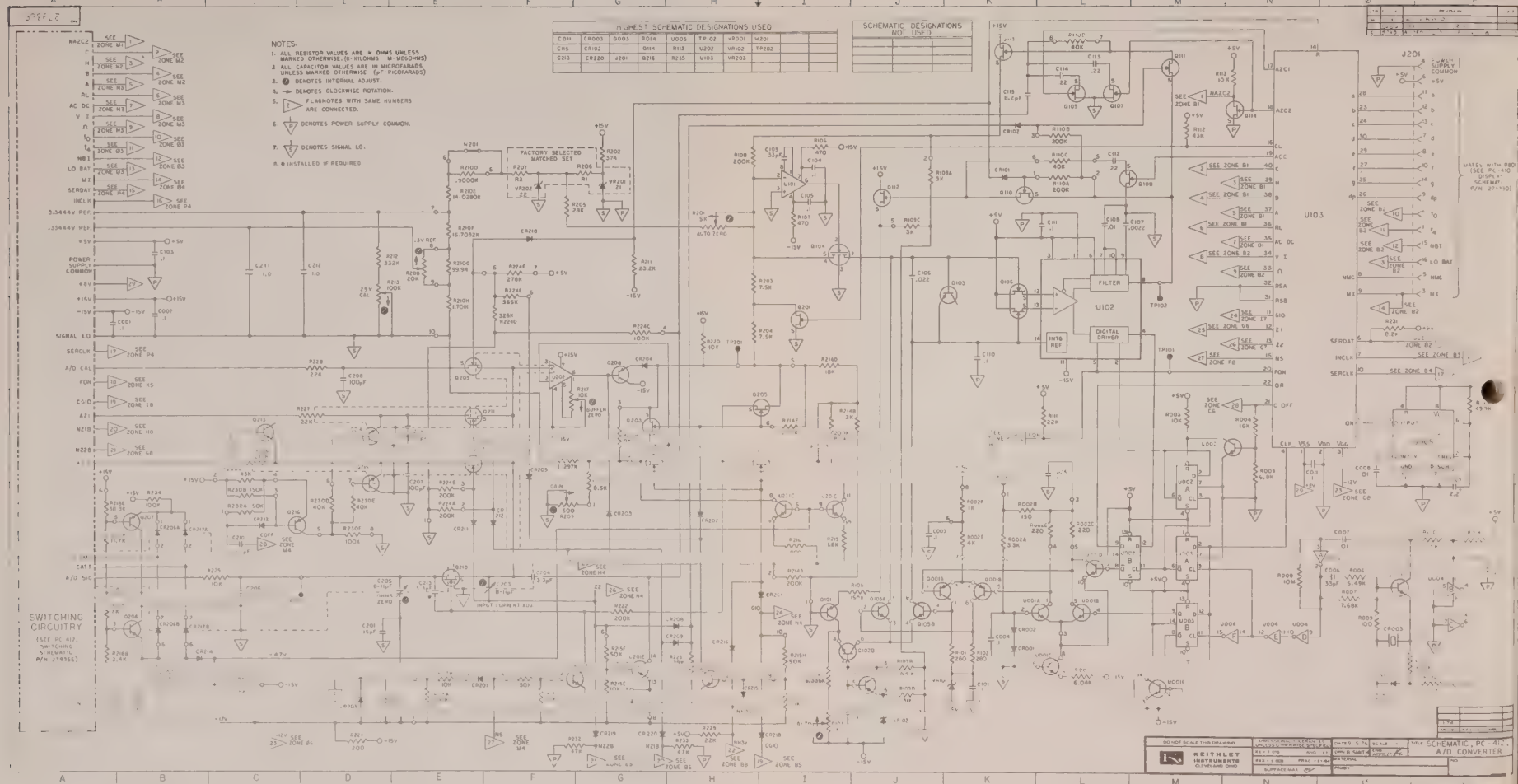
7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____°F. Variation? _____°F. Rel. Humidity? _____
   Other _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

_____ REV 0774


FUNCTION SWITCH
SWITCH SIDE VIEW
SWITCH FRONT VIEW
DECK 1
DECK 2
DECK 3
DECK 4
S301 RANGE SWITCH
POWER SUPPLY
(SEE SCHEMATIC P/N 279380)
P301
MATES WITH J1203 (SEE AC/DC CONVERTER SCHEMATIC 27944D)
NANOVOLT PRE-AMP
(SEE SCHEMATIC P/N 27937D)
A/D SECTION
(SEE A/D SCHEMATIC P/N 27936F)
P505
MATES WITH J1002 (SEE CURRENT BOARD, MODEL 1745, SCHEMATIC P/N 27940C)
P504
MATES WITH J1001 (SEE CURRENT BOARD, MODEL 1745, SCHEMATIC P/N 27940C)
P902 MATES WITH J702
P903 MATES WITH J703
P904 MATES WITH J704
P905 MATES WITH J705
(SEE DIGITAL BOARD SCHEMATIC P/N 28209E)
P501
MATES WITH J1201 (SEE AC/DC CONV. SCHEM 27944D)
P502
MATES WITH J1202 (SEE AC/DC CONV. SCHEM 27944D)
P503
MATES WITH J1101 (SEE OHMS CIRCUIT, MODEL 1744, SCHEMATIC P/N 27941C)
TYPICAL PUSH BUTTON SWITCH, TOP VIEW
NOTES
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K=KILOHMS, M=MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF PICOFARADS)
3. ○ DENOTES FRONT PANEL CONTROL
4. ⊘ DENOTES INTERNAL ADJUST
5. → DENOTES CLOCKWISE ROTATION
6. ▽P DENOTES POWER SUPPLY COMMON (PSC).
7. ▽ DENOTES SIGNAL LO.
8. ⏚ DENOTES CHASSIS CONNECTION
9. ROTARY SWITCH SHOWN IN C.C.W. POSITION.
10. ALL PUSH-BUTTON SWITCH CONTACTS ARE SHOWN IN THE PUSH BUTTON OUT POSITION.
11. RESISTORS R523 & R524 ARE MOUNTED ON THE DISPLAY BOARD SHIELD AND R525 ON SWITCH S302
SCHEMATIC DESIGNATIONS NOT USED
J301 P901 R501 R502
R514 CR502
HIGHEST SCHEMATIC DESIGNATIONS USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, SWITCHING, PC-412
27935E


HIGHEST SCHEMATIC DESIGNATIONS USED
SCHEMATIC DESIGNATIONS NOT USED
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K=KILOHMS M=MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS, UNLESS MARKED OTHERWISE (pF=PICOFARADS)
3. ⓐ DENOTES INTERNAL ADJUST.
4. → DENOTES CLOCKWISE ROTATION.
5. FLAGNOTES WITH SAME NUMBERS ARE CONNECTED.
6. DENOTES POWER SUPPLY COMMON.
7. DENOTES SIGNAL LO.
8. ● INSTALLED IF REQUIRED
SWITCHING CIRCUITRY
(SEE PC 412, SWITCHING SCHEMATIC P/N 27935E)
FACTORY SELECTED MATCHED SET
U103
U102
U101
J201
FILTER
INTG REF
DIGITAL DRIVER
REITHLET INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, PC-412, A/D CONVERTER

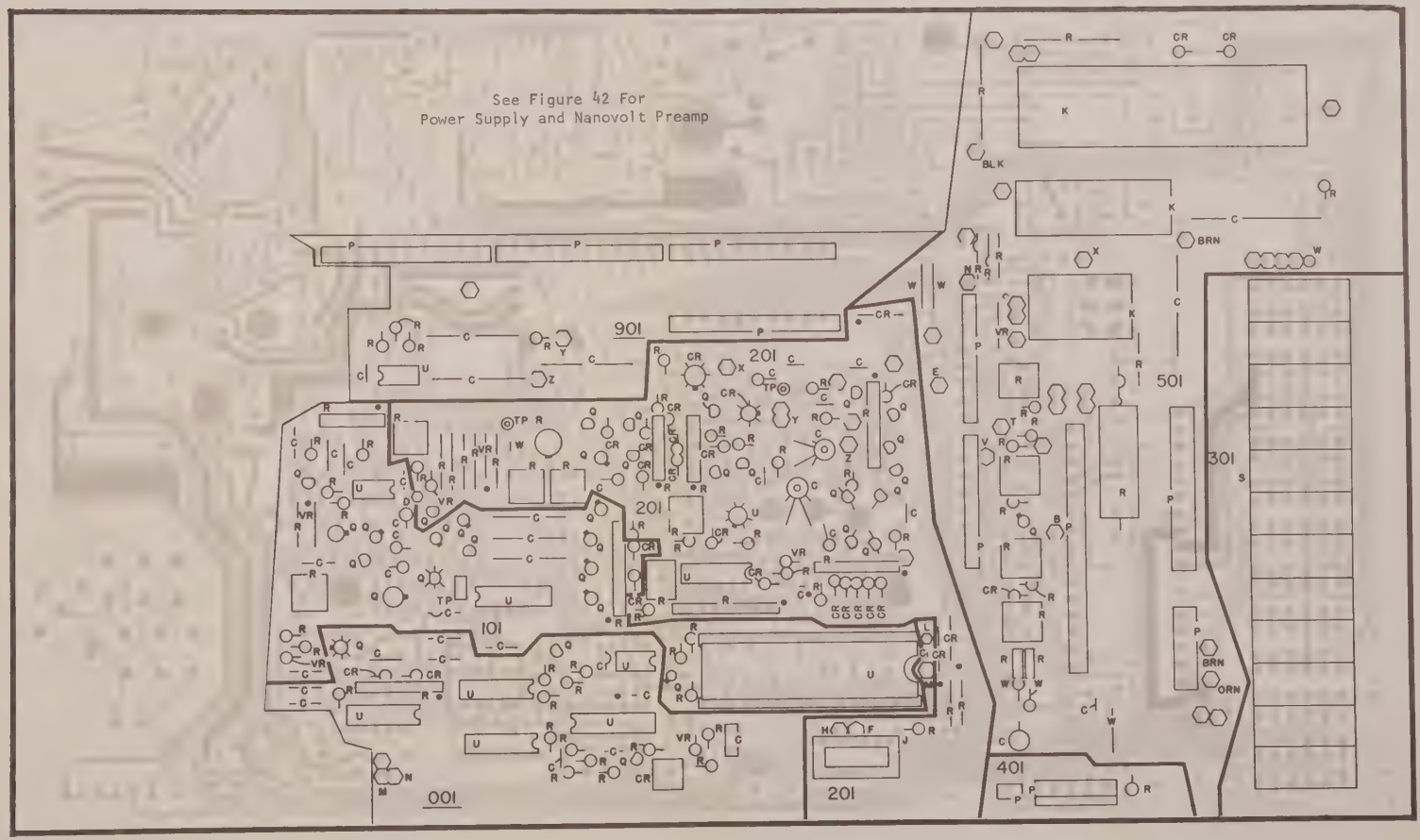


FIGURE 41. Component Layout, PC-412 (Part 1)
(Shows Switching and A/D Converter)

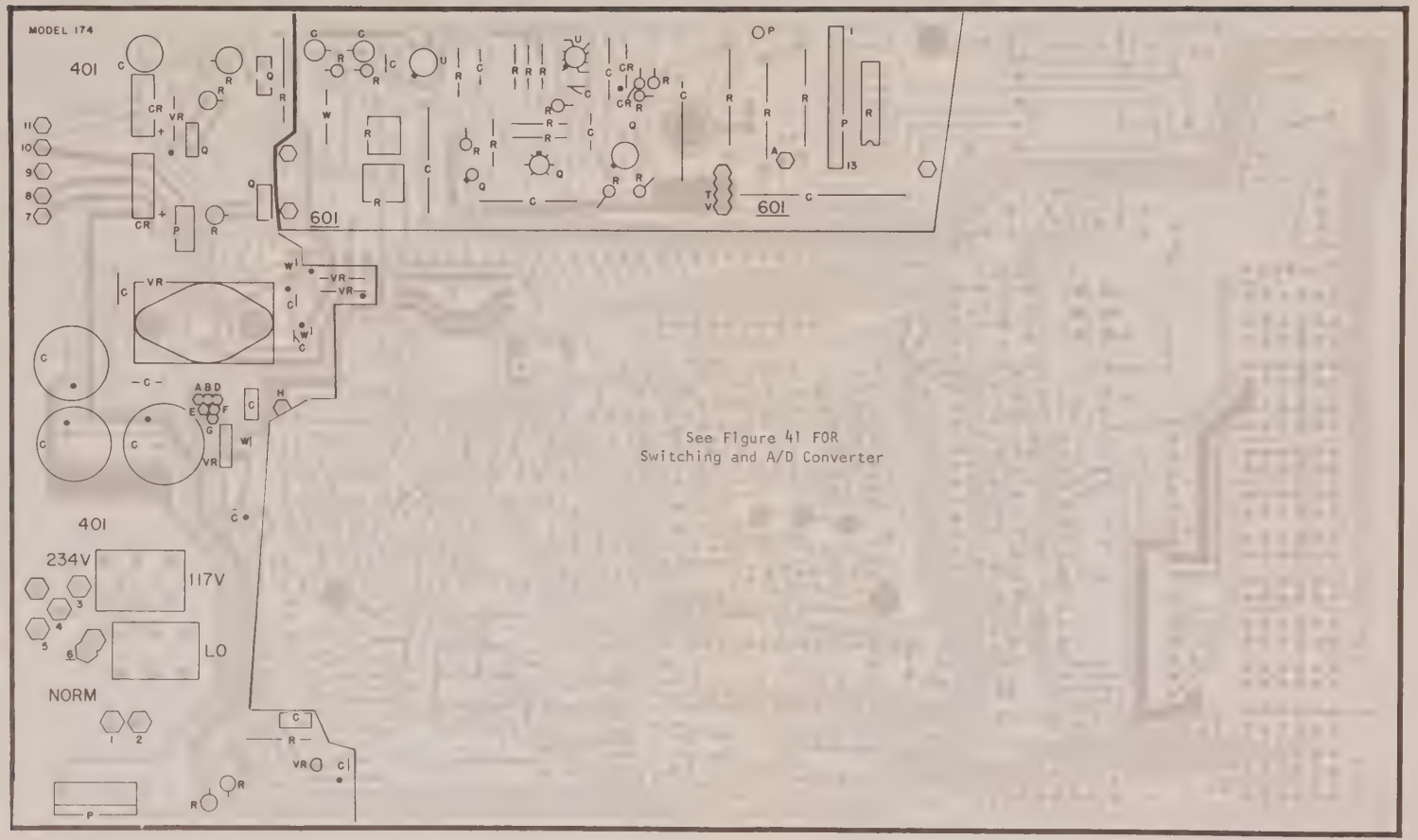
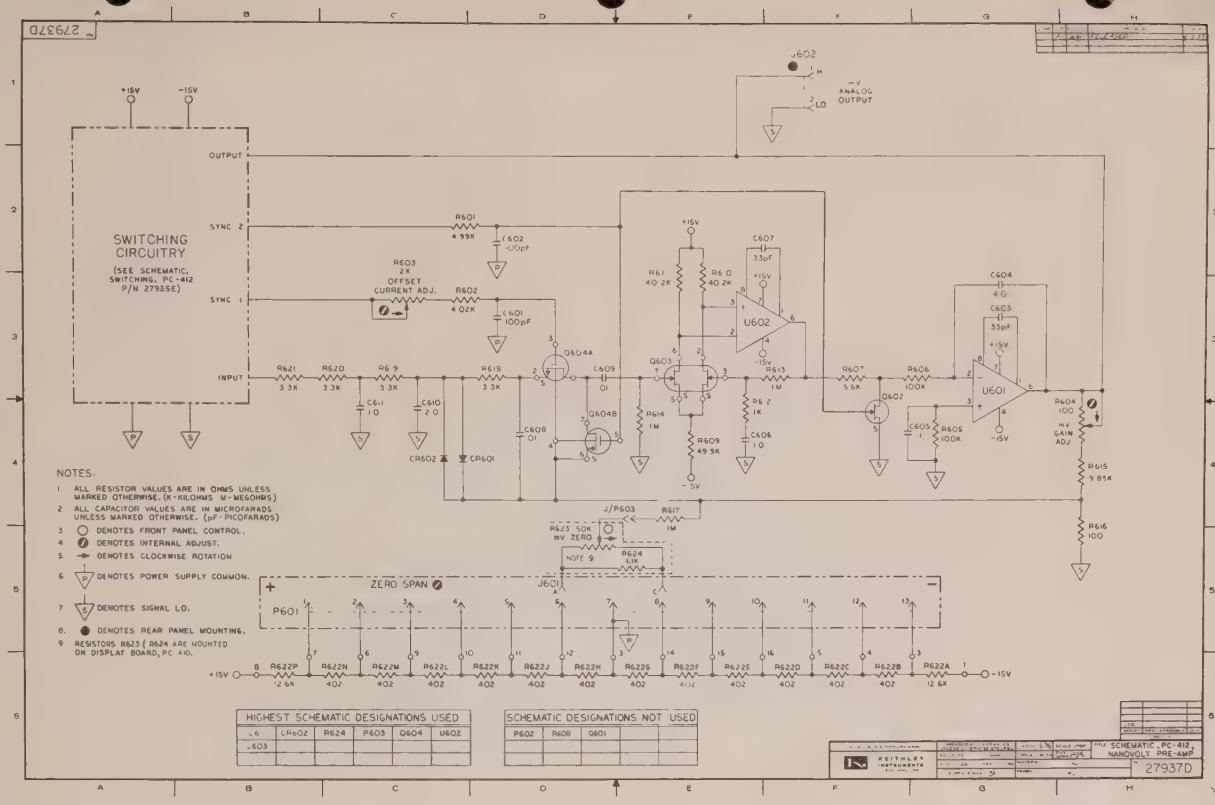
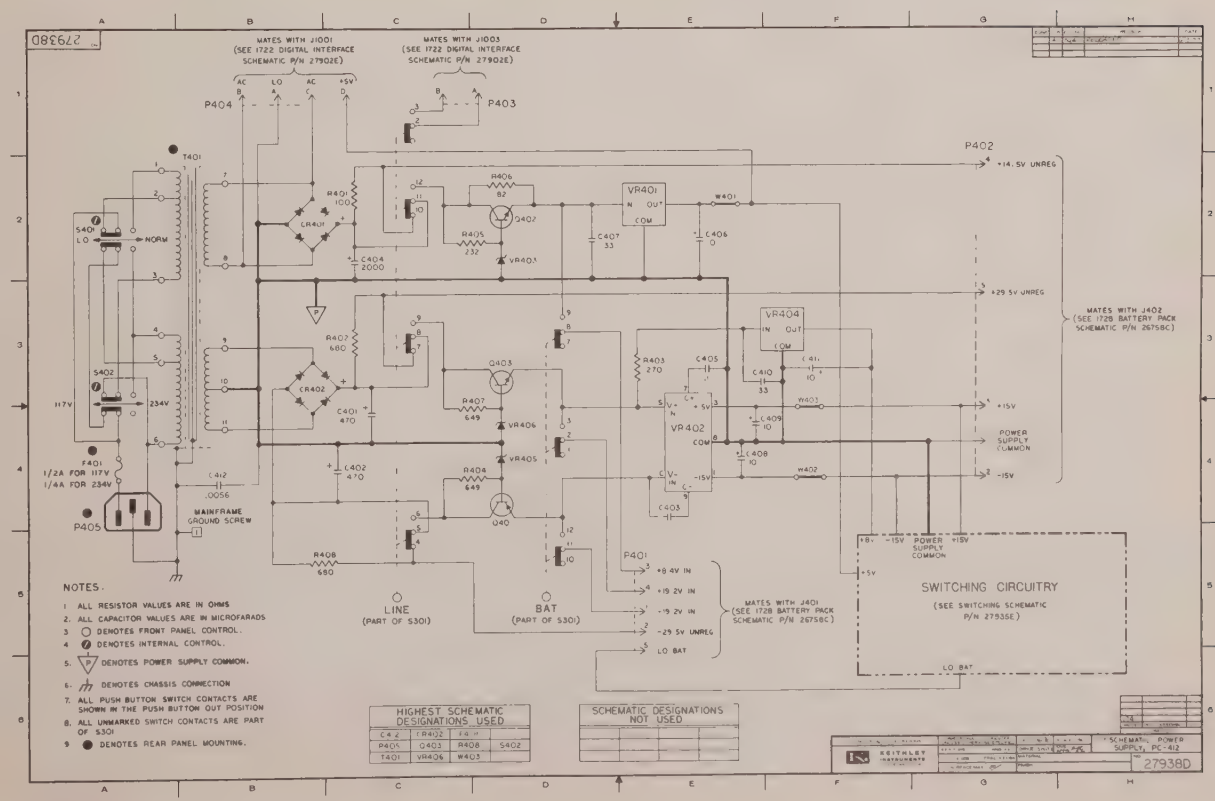
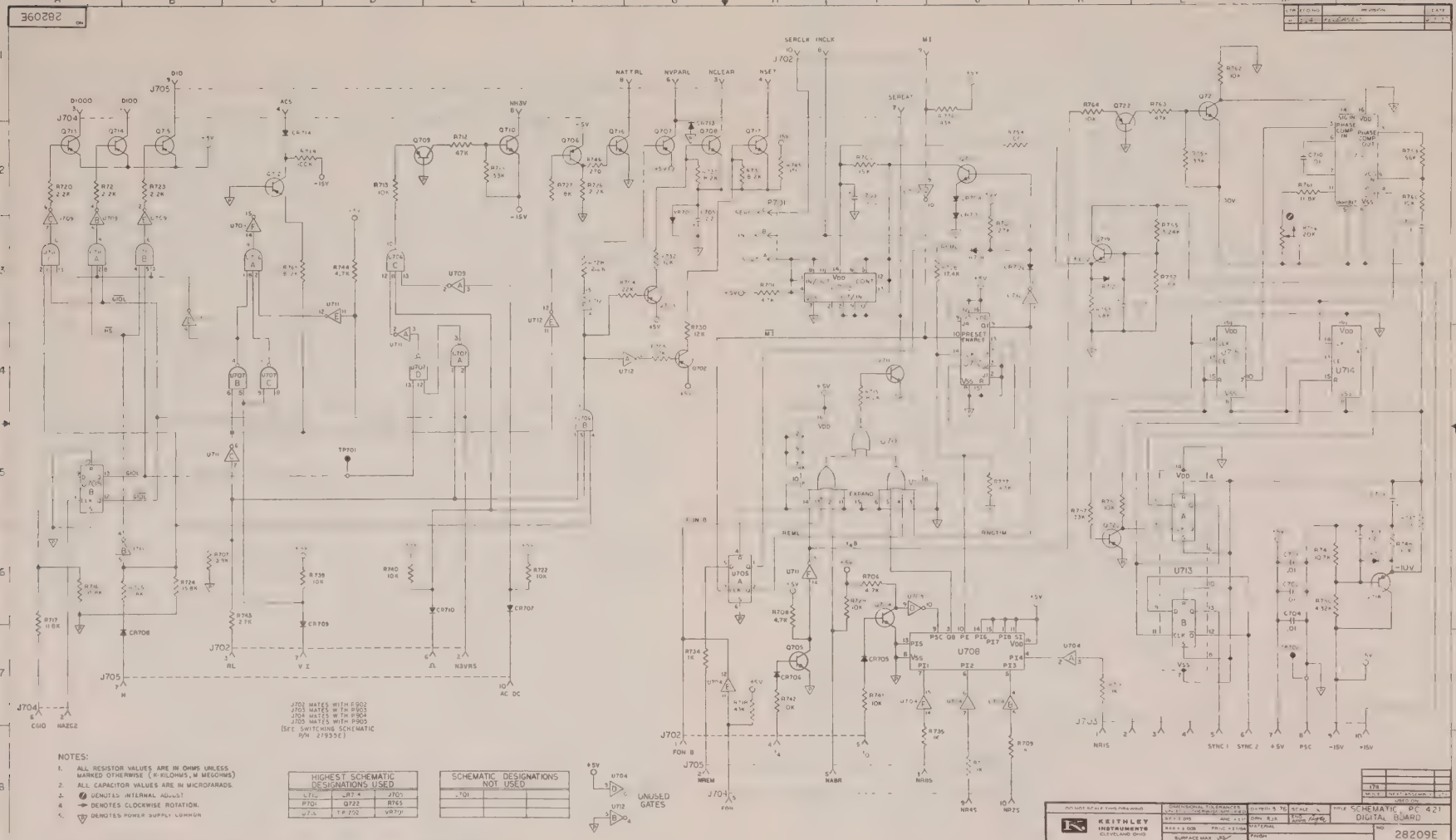


FIGURE 42. Component Layout, PC-412 (Part 2)
(Shows Nanovolt Preamp and Power Supply)


J602
HI
LO
mV ANALOG OUTPUT
+15V
-15V
OUTPUT
SYNC 2
SYNC 1
INPUT
SWITCHING CIRCUITRY
(SEE SCHEMATIC, SWITCHING, PC-412 P/N 27935E)
R601 4.99K
C602 100pF
R603 2K OFFSET CURRENT ADJ.
R602 4.02K
C601 100pF
R621 3.3K
R620 3.3K
R619 3.3K
R618 3.3K
C611 10
C610 2.0
C608 .01
C609 .01
CR602
CR601
Q604A
Q604B
R614 1M
R609 49.9K
R61 40.2K
R60 40.2K
C607 33pF
U602
Q603
R613 1M
R612 1K
C606 10
R607 5.6K
R606 100K
Q602
C605
R605 100K
C604 4.0
C603 33pF
U601
R604 100 mV GAIN ADJ
R615 9.85K
R616 100
J/P603
R617 1M
R623 50K mV ZERO
R624 41K
NOTE 9
ZERO SPAN
J601
P601
R622P 12.6K
R622N 402
R622M 402
R622L 402
R622K 402
R622J 402
R622H 402
R622G 402
R622F 402
R622E 402
R622D 402
R622C 402
R622B 402
R622A 12.6K
+15V
-15V
NOTES.
1 ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS M-MEGOHMS)
2 ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3 ○ DENOTES FRONT PANEL CONTROL.
4 ⊘ DENOTES INTERNAL ADJUST.
5 → DENOTES CLOCKWISE ROTATION
6 ▽P DENOTES POWER SUPPLY COMMON.
7 ▽S DENOTES SIGNAL LO.
8 ● DENOTES REAR PANEL MOUNTING.
9 RESISTORS R623 & R624 ARE MOUNTED ON DISPLAY BOARD, PC 410.
HIGHEST SCHEMATIC DESIGNATIONS USED
C606 R602 R624 P603 Q604 U602
J603
SCHEMATIC DESIGNATIONS NOT USED
P602 R608 Q601
KEITHLEY INSTRUMENTS
SCHEMATIC, PC-412, NANOVOLT PRE-AMP
27937D


MATES WITH J1001 (SEE 1722 DIGITAL INTERFACE SCHEMATIC P/N 27902E)
MATES WITH J1003 (SEE 1722 DIGITAL INTERFACE SCHEMATIC P/N 27902E)
AC LO AC +5V
P404
P403
T401
S401 LO NORM
S402 117V 234V
F401 1/2A FOR 117V 1/4A FOR 234V
P405
MAINFRAME GROUND SCREW
CR401
CR402
R401 100
R402 680
R403 270
R404 649
R405 232
R406 82
R407 649
R408 680
C401 470
C402 470
C403 .0056
C404 2000
C405 .1
C406 0
C407 33
C408 10
C409 10
C410 33
C411 10
C412 .1
Q401
Q402
Q403
Q404
VR401 IN OUT COM
VR402 V+ IN COM V- IN
VR403
VR404 IN OUT COM
VR405
VR406
W401
W402
W403
P402
+14.5V UNREG
+29.5V UNREG
+15V
POWER SUPPLY COMMON
-15V
MATES WITH J402 (SEE 1728 BATTERY PACK SCHEMATIC P/N 26758C)
P401
+8.4V IN
+19.2V IN
-19.2V IN
-29.5V UNREG
LO BAT
MATES WITH J401 (SEE 1728 BATTERY PACK SCHEMATIC P/N 26758C)
LINE (PART OF S301)
BAT (PART OF S301)
+8V -15V POWER SUPPLY COMMON +15V +5V
SWITCHING CIRCUITRY
(SEE SWITCHING SCHEMATIC P/N 27935E)
LO BAT
NOTES.
1 ALL RESISTOR VALUES ARE IN OHMS
2. ALL CAPACITOR VALUES ARE IN MICROFARADS
3 ○ DENOTES FRONT PANEL CONTROL.
4 ⊘ DENOTES INTERNAL CONTROL.
5. ▽P DENOTES POWER SUPPLY COMMON.
6. DENOTES CHASSIS CONNECTION
7. ALL PUSH BUTTON SWITCH CONTACTS ARE SHOWN IN THE PUSH BUTTON OUT POSITION
8. ALL UNMARKED SWITCH CONTACTS ARE PART OF S301
9 ● DENOTES REAR PANEL MOUNTING.
HIGHEST SCHEMATIC DESIGNATIONS USED
C412 R402 R408
P405 Q403 S402
T401 VR406 W403
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS
SCHEMATIC, POWER SUPPLY, PC-412
27938D


J704
J705
J702
J703
U708
U713
U714
U712
U711
U710
U709
U707
U706
Q705
Q706
Q707
Q708
Q709
Q710
Q711
Q712
Q713
Q714
Q715
Q716
Q717
Q718
Q719
Q720
Q721
Q722
Q723
Q724
Q725
Q726
Q727
Q728
Q729
Q730
Q731
Q732
Q733
Q734
Q735
Q736
Q737
Q738
Q739
Q740
Q741
Q742
Q743
Q744

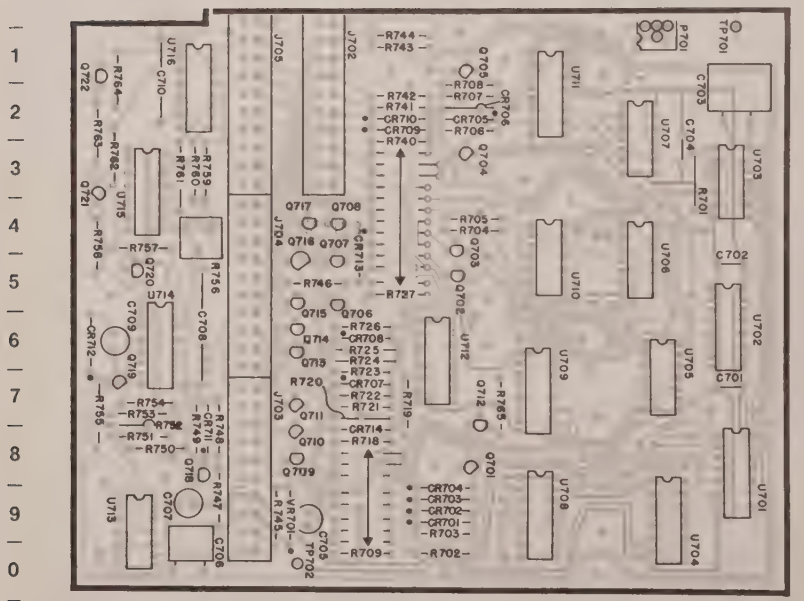
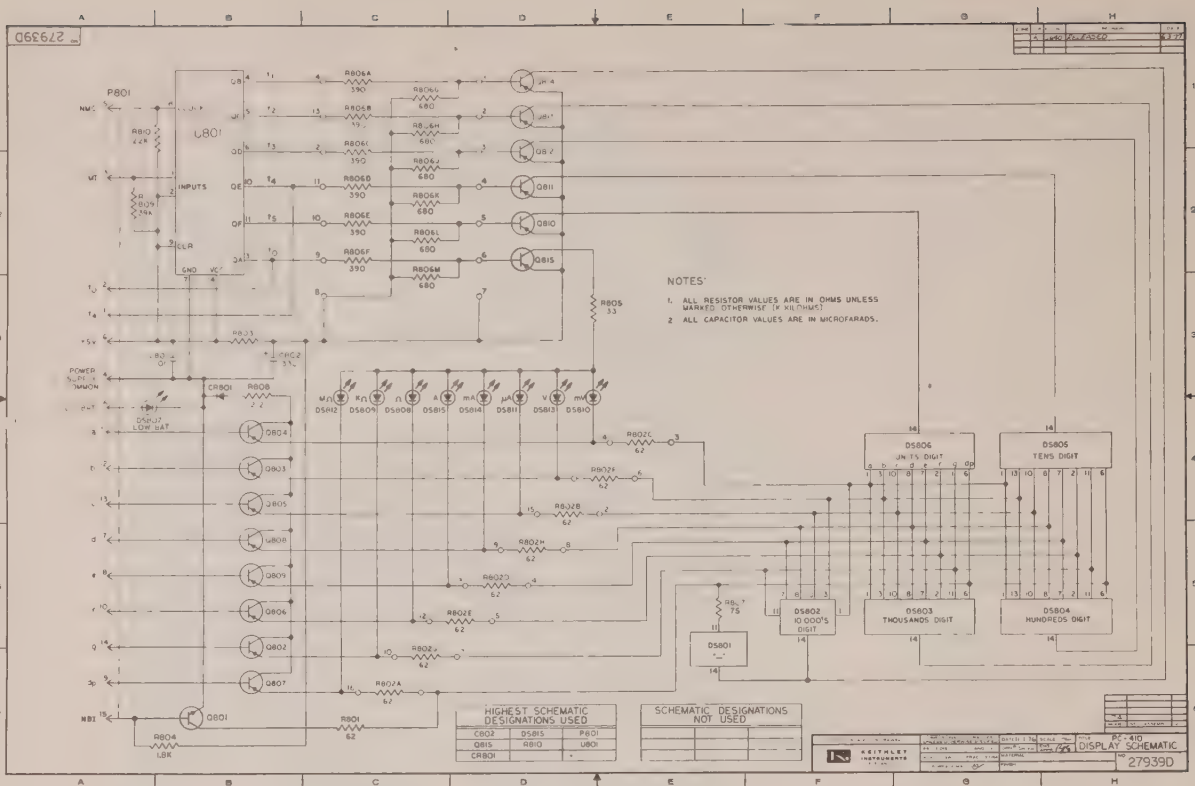


FIGURE 43. Component Layout, PC-421.



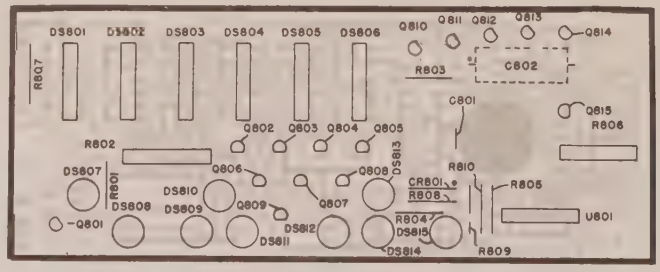
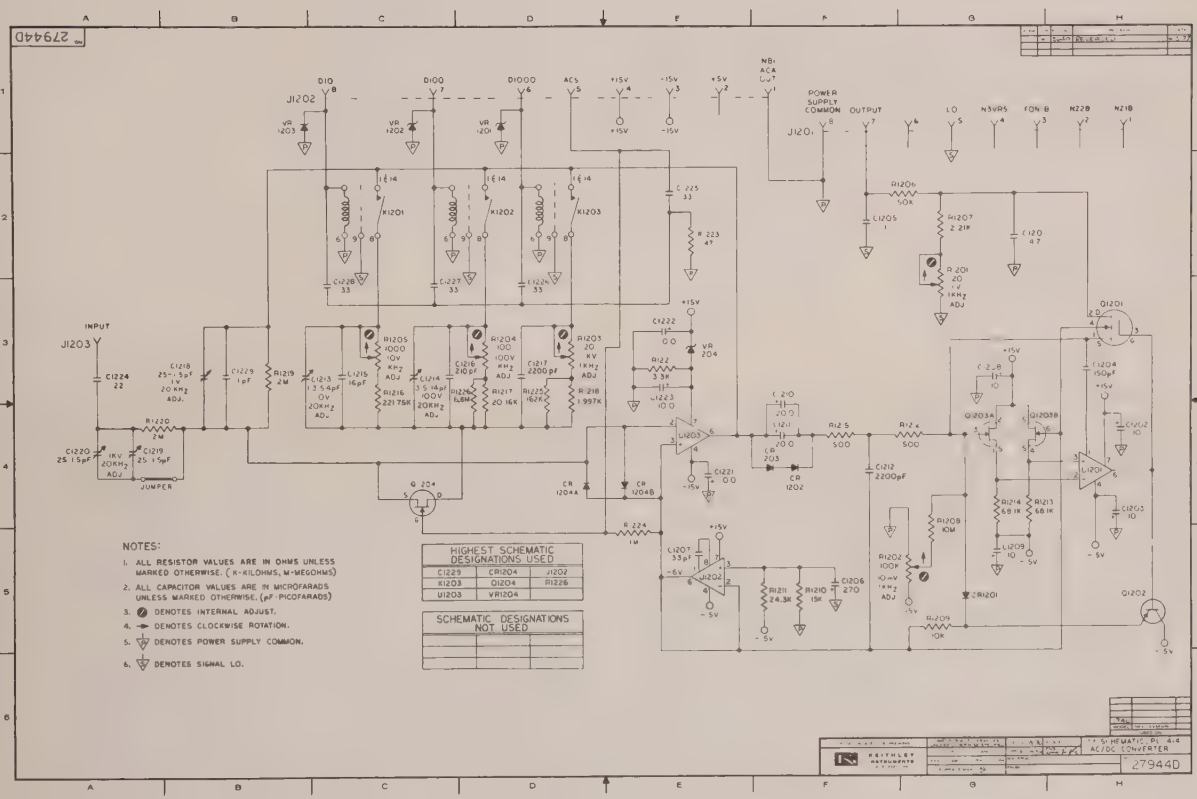


FIGURE 44. Component Layout, PC-410.



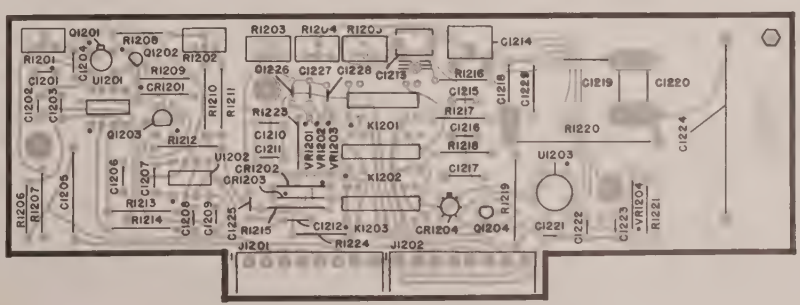
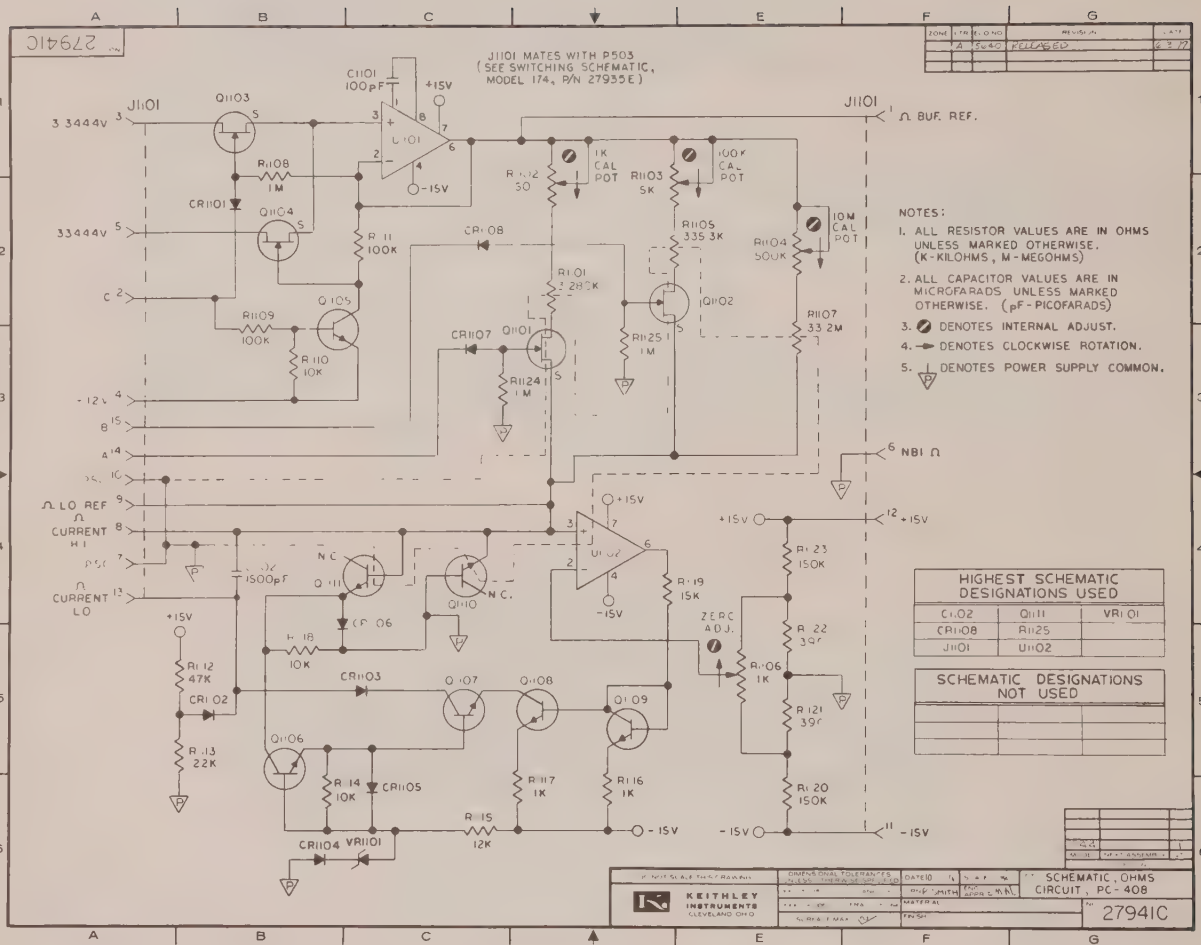


FIGURE 45. Component Layout, PC-414.


J1101 MATES WITH P503 (SEE SWITCHING SCHEMATIC, MODEL 174, P/N 27935E)
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3. DENOTES INTERNAL ADJUST.
4. DENOTES CLOCKWISE ROTATION.
5. DENOTES POWER SUPPLY COMMON.
HIGHEST SCHEMATIC DESIGNATIONS USED
C1102 Q1111 VR1101
CR1108 R1125
J1101 U1102
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, OHMS CIRCUIT, PC-408
27941C

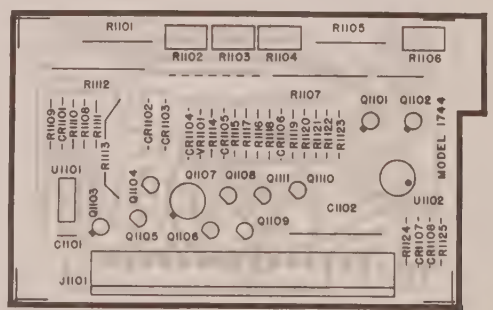


FIGURE 46. Component Layout, PC-408.

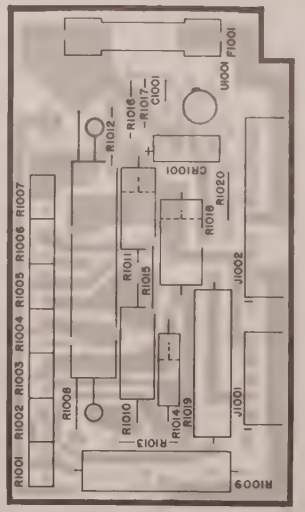
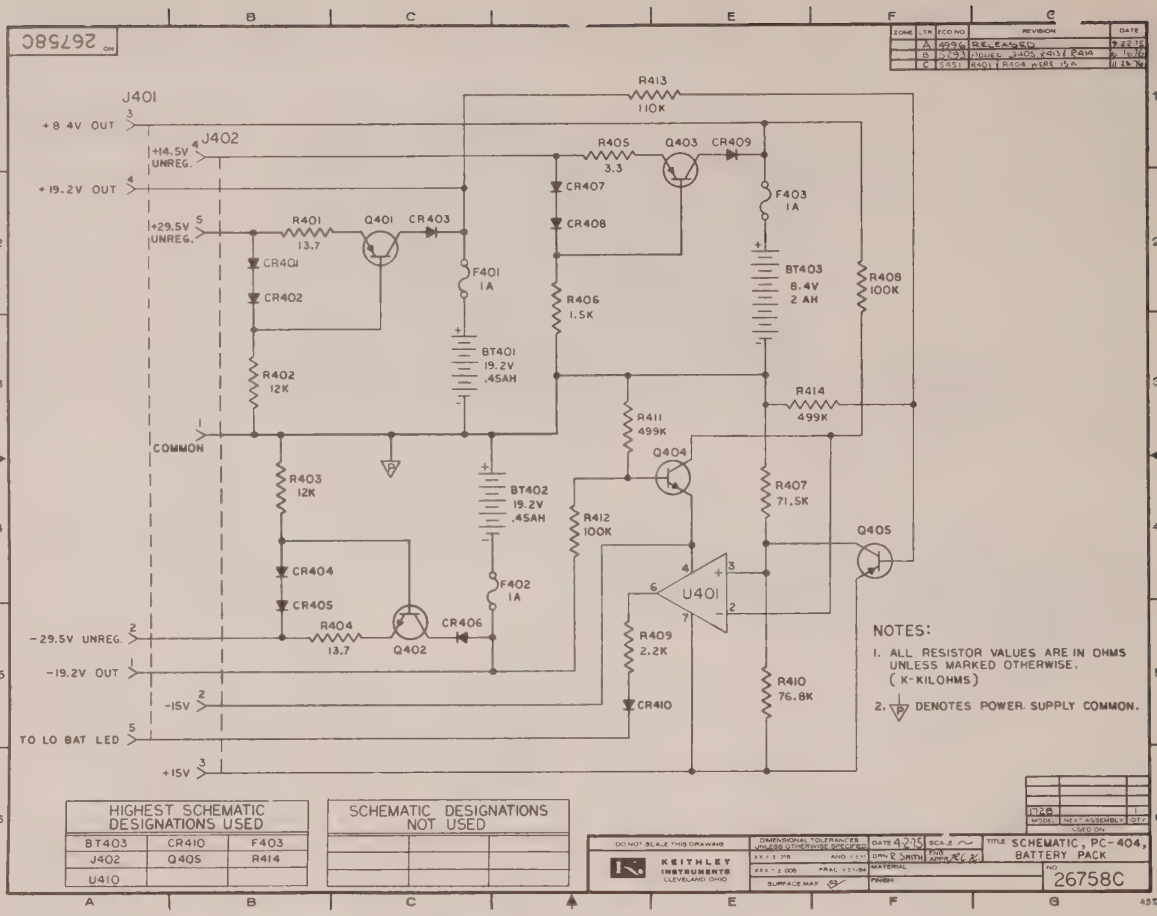
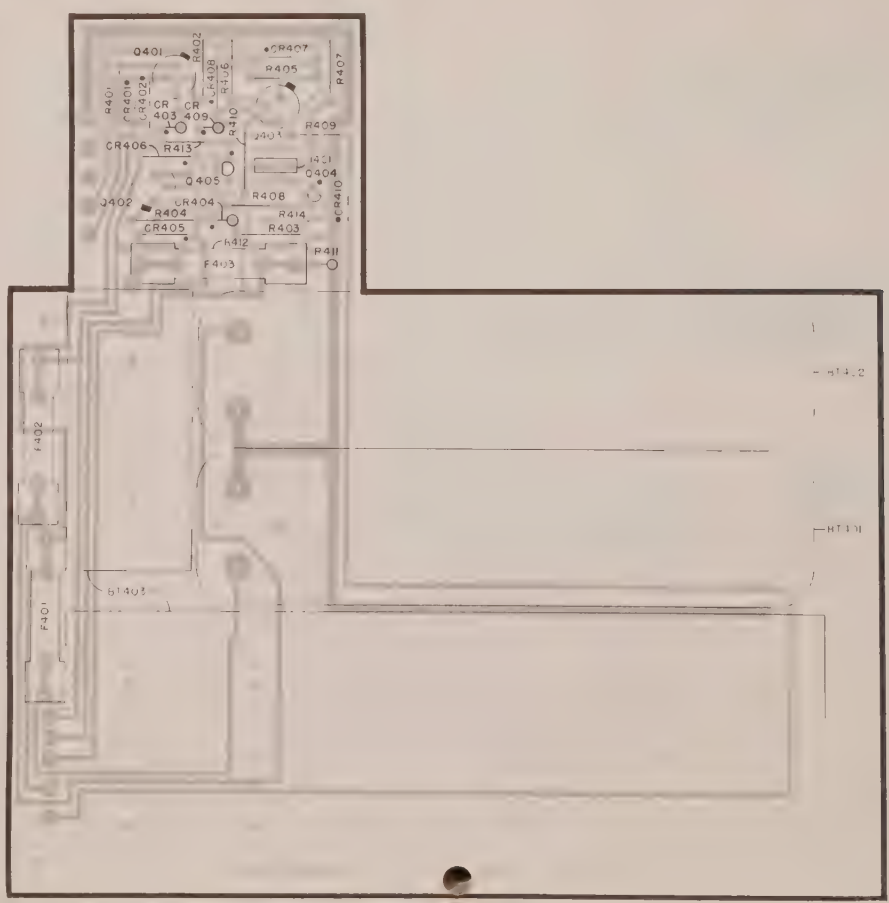
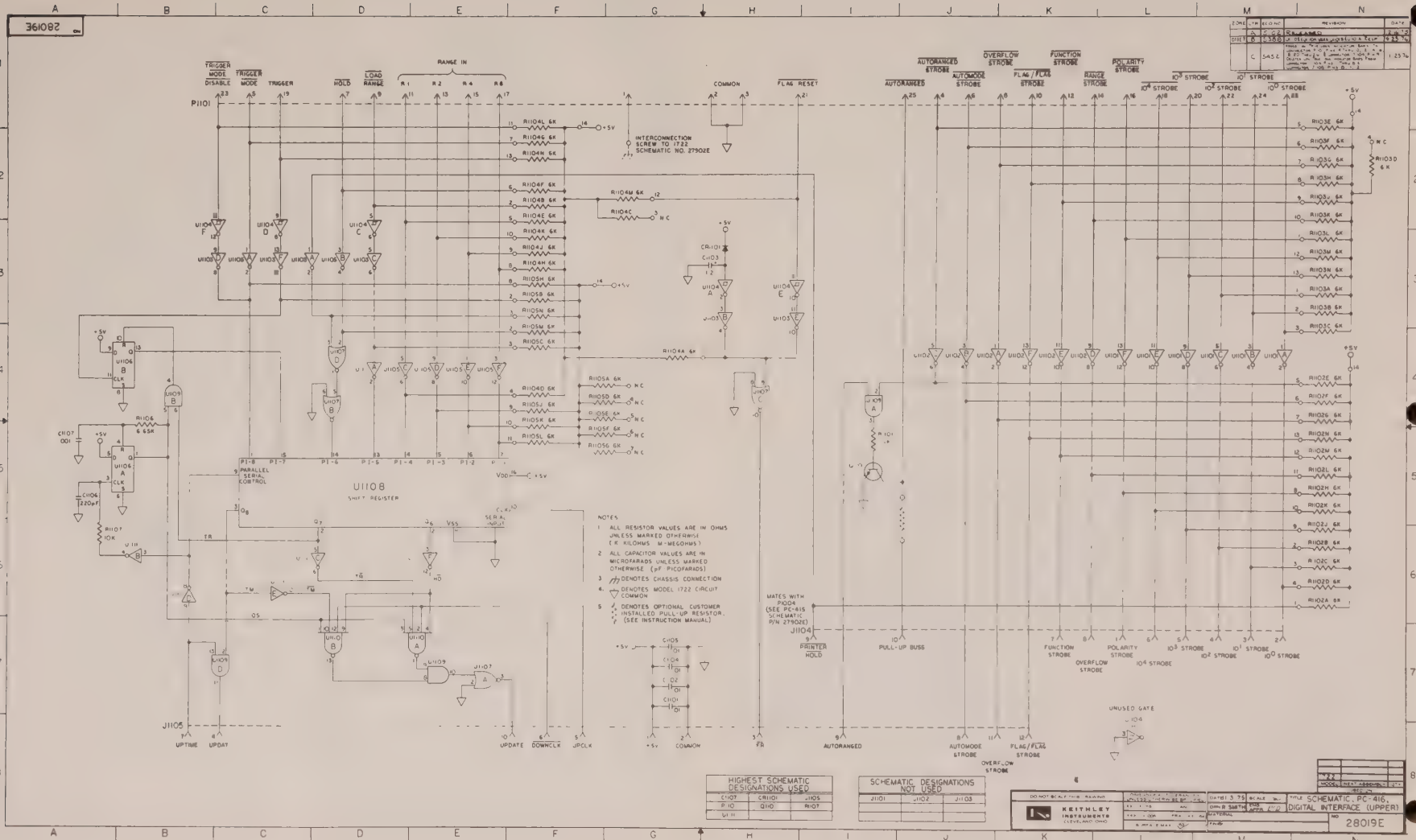


FIGURE 47. Component Layout, PC-409.


J401
+8.4V OUT
J402
+14.5V UNREG.
+19.2V OUT
+29.5V UNREG.
COMMON
-29.5V UNREG.
-19.2V OUT
-15V
TO LO BAT LED
+15V
R413 110K
R405 3.3
Q403
CR409
CR407
CR408
F403 1A
BT403 8.4V 2 AH
R408 100K
R401 13.7
Q401
CR403
CR401
CR402
F401 1A
R406 1.5K
BT401 19.2V .45AH
R402 12K
R411 499K
R414 499K
R403 12K
Q404
R407 71.5K
BT402 19.2V .45AH
R412 100K
Q405
CR404
CR405
F402 1A
U401
R404 13.7
Q402
CR406
R409 2.2K
CR410
R410 76.8K
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS)
2. DENOTES POWER SUPPLY COMMON.
HIGHEST SCHEMATIC DESIGNATIONS USED
BT403 CR410 F403
J402 Q405 R414
U410
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
TITLE SCHEMATIC, PC-404, BATTERY PACK
NO 26758C


Q401
R402
CR407
R405
R407
R401
CR401
CR402
R408
R406
CR 403
CR 409
R410
J401
R409
CR406
R413
J451
Q404
Q405
J402
R408
CR404
R404
R414
CR410
CR405
R403
R412
R411
F403
F402
F401
B1403


TRIGGER MODE DISABLE
TRIGGER MODE
TRIGGER
HOLD
LOAD RANGE
RANGE IN
R1 R2 R4 R8
COMMON
FLAG RESET
AUTORANGED STROBE
OVERFLOW STROBE
FUNCTION STROBE
POLARITY STROBE
AUTORANGED
AUTOMODE STROBE
FLAG/FLAG STROBE
RANGE STROBE
10³ STROBE
10² STROBE
10¹ STROBE
10⁰ STROBE
P1101
INTERCONNECTION SCREW TO 1722 SCHEMATIC NO. 27902E
U1108
SHIFT REGISTER
PARALLEL / SERIAL CONTROL
SERIAL INPUT
NOTES
1 ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE (K KILOHMS M-MEGOHMS)
2 ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE (pF PICOFARADS)
3 DENOTES CHASSIS CONNECTION
4 DENOTES MODEL 1722 CIRCUIT COMMON
5 DENOTES OPTIONAL CUSTOMER INSTALLED PULL-UP RESISTOR. (SEE INSTRUCTION MANUAL)
MATES WITH P004 (SEE PC-615 SCHEMATIC P/N 27902E)
J1104
PRINTER HOLD
PULL-UP BUSS
FUNCTION STROBE
OVERFLOW STROBE
POLARITY STROBE
10⁴ STROBE
10³ STROBE
10² STROBE
10¹ STROBE
10⁰ STROBE
J1105
UPTIME
UPDAT
UPDATE
DOWNCLK
JPCLK
+5V
COMMON
FR
AUTORANGED
AUTOMODE STROBE
FLAG/FLAG STROBE
OVERFLOW STROBE
UNUSED GATE
U104
HIGHEST SCHEMATIC DESIGNATIONS USED
C107 C1101 J1105
P10 Q10 R107
U11
SCHEMATIC DESIGNATIONS NOT USED
J1101 J1102 J1103
KEITHLEY INSTRUMENTS (CLEVELAND OHIO)
DO NOT SCALE THIS DRAWING
DATE 1-3-75
DRN R SMITH
APPR
MATERIAL
FINISH
SCALE
TITLE SCHEMATIC, PC-416, DIGITAL INTERFACE (UPPER)
NO 28019E

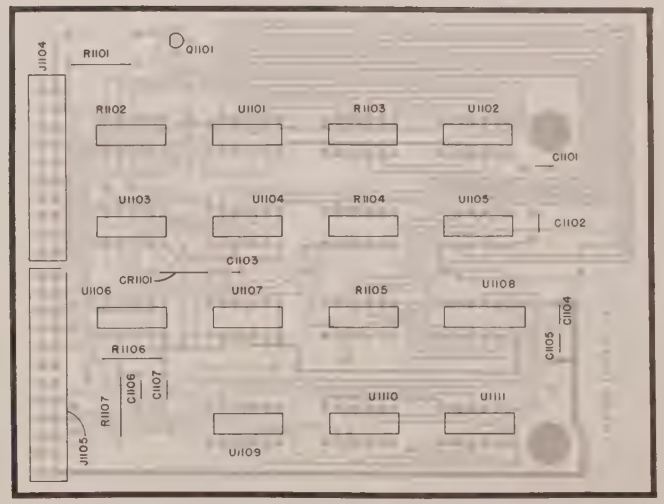
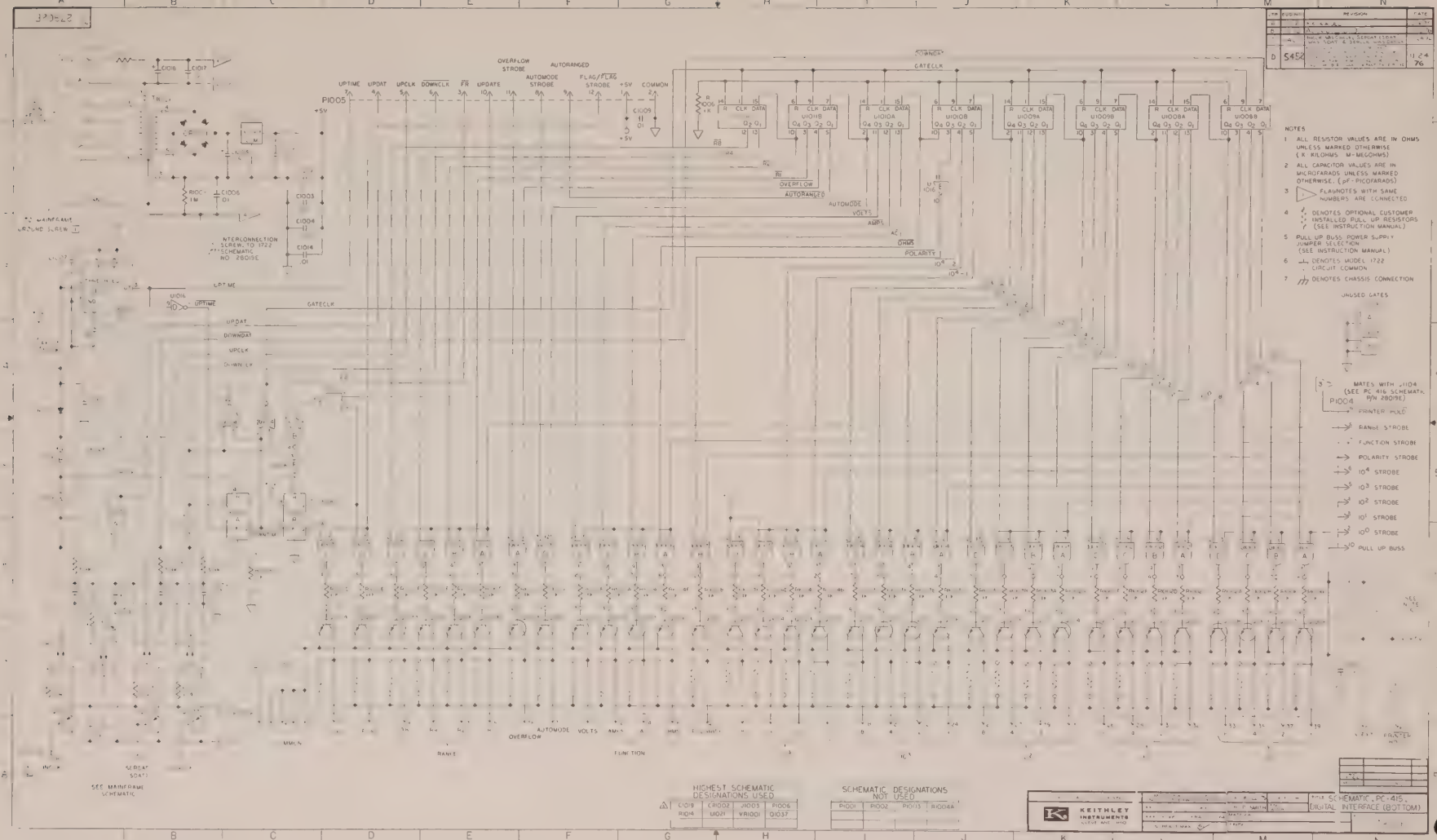


FIGURE 49. Component Layout, Model 1722, Upper Board (PC-416).


P1005
UPTIME
UPDAT
UPCLK
DOWNCLR
FR
UPDATE
OVERFLOW STROBE
AUTOMODE STROBE
AUTORANGED
FLAG/FCRS STROBE
+5V
COMMON
GATECLK
OVERFLOW
AUTORANGED
AUTOMODE
VOLTS
AMPS
OHMS
POLARITY
INTERCONNECTION SCREW TO 1722 SCHEMATIC NO 28015E
TO MAINFRAME GROUND SCREW
LPT ME
DOWNDAT
DOWNCLK
P1004
PRINTER BUSS
RANGE STROBE
FUNCTION STROBE
POLARITY STROBE
PULL UP BUSS
MATES WITH J1004 (SEE PC 416 SCHEMATIC P/N 28019E)
UNUSED GATES
NOTES
1 ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE (K KILOHMS M-MEGOHMS)
2 ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3 FLAGNOTES WITH SAME NUMBERS ARE CONNECTED
4 DENOTES OPTIONAL CUSTOMER INSTALLED PULL UP RESISTORS (SEE INSTRUCTION MANUAL)
5 PULL UP BUSS POWER SUPPLY JUMPER SELECTION (SEE INSTRUCTION MANUAL)
6 DENOTES MODEL 1722 CIRCUIT COMMON
7 DENOTES CHASSIS CONNECTION
RANGE
FUNCTION
OVERFLOW
AUTOMODE
VOLTS
AMPS
SERIAL PORT
SEE MAINFRAME SCHEMATIC
HIGHEST SCHEMATIC DESIGNATIONS USED
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS
SCHEMATIC, PC-415, DIGITAL INTERFACE (BOTTOM)

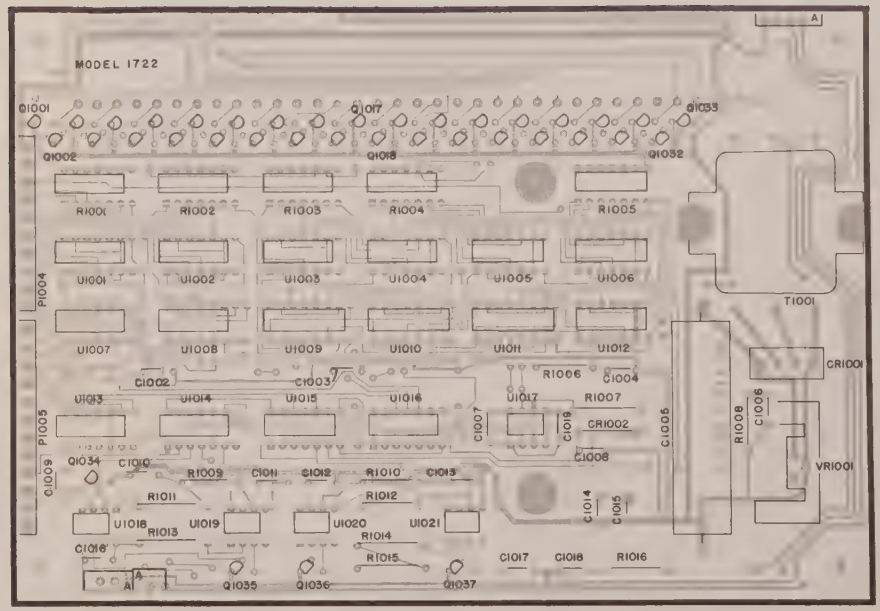


FIGURE 50. Component Layout, Model 1722, Lower Board (PC-415).

FIGURE 7A

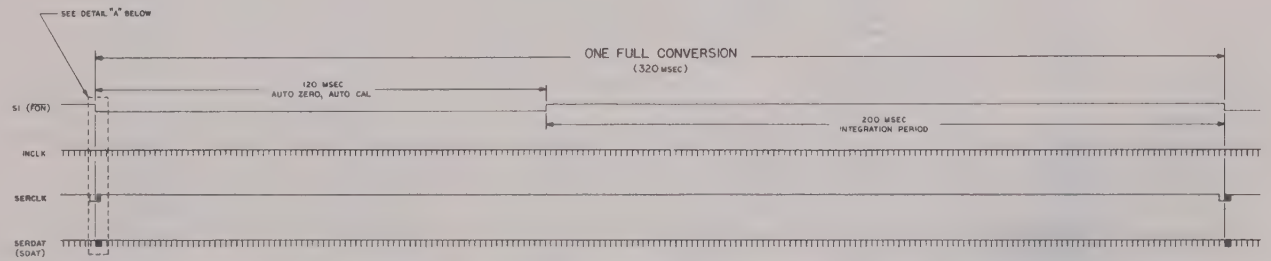
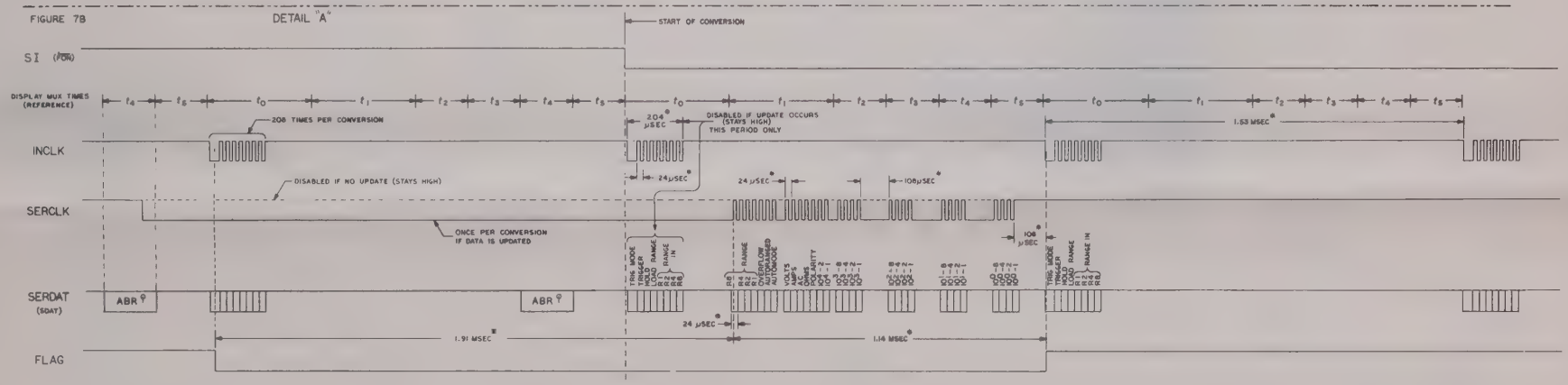


FIGURE 7B



NOTES:

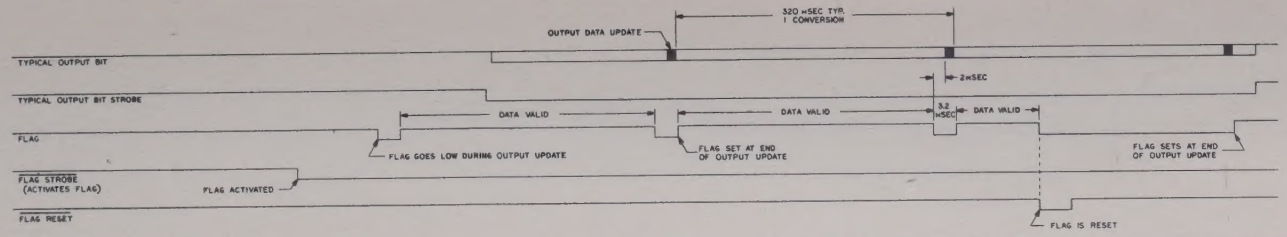
1. * TIMES ARE TYPICAL AND DEPEND ON DMM MASTER CLOCK.
2. ? 174 ONLY, EXTENDED RANGE SELECTION BIT.

DO NOT SCALE THIS DRAWING	DATE 4-6-76	TITLE TIMING DIAGRAM, MODEL 1722 INPUTS
KEITHLEY INSTRUMENTS CLEVELAND, OHIO	DRN R. SMITH	NO. 28247E

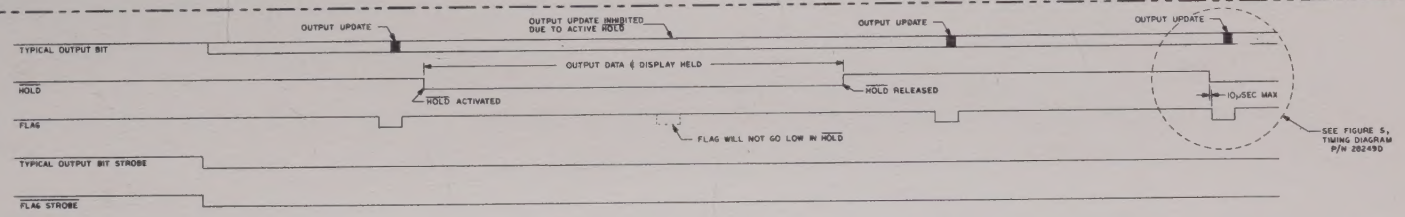
28248E

LTR	ECO NO	REVISION	DATE
A	5422	RELEASED	11-11-76
B	5452	HOLD ON TRUE 1 DISC INDICATOR BIT 5; FLAG RESET T/AL STROBE HOLD/LOAD RANGE; RANGE STROBE (TYPICAL) 3 MODE + TRIGGER MODE	11-23-76

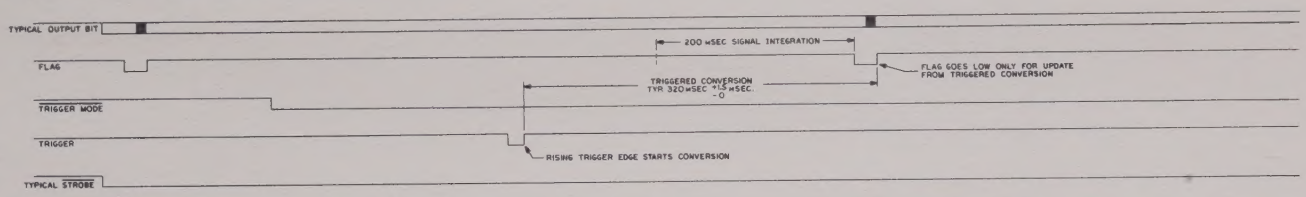
DATA & FLAG
FIGURE 1



HOLD
FIGURE 2

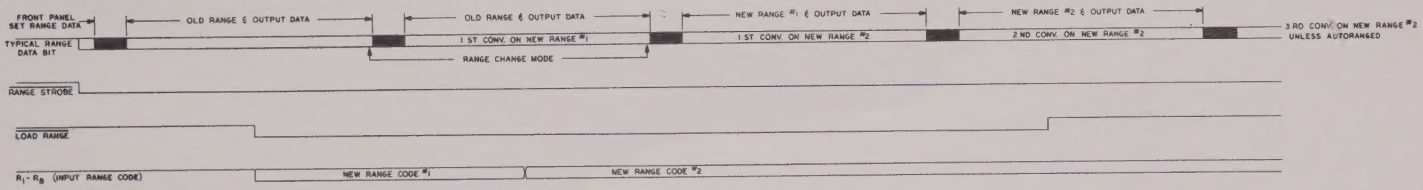


TRIGGER MODE
FIGURE 3



RANGE PROGRAMMING
FIGURE 4

(TRIGGER MODE & TRIGGER NOT ACTIVATED)


FRONT PANEL SET RANGE DATA
OLD RANGE & OUTPUT DATA
OLD RANGE & OUTPUT DATA
NEW RANGE #1 & OUTPUT DATA
NEW RANGE #2 & OUTPUT DATA
TYPICAL RANGE DATA BIT
1 ST CONV. ON NEW RANGE #1
1 ST CONV. ON NEW RANGE #2
2 ND CONV. ON NEW RANGE #2
3 RD CONV. ON NEW RANGE #2 UNLESS AUTORANGED
RANGE CHANGE MODE
RANGE STROBE
LOAD RANGE
R1 - R8 (INPUT RANGE CODE)
NEW RANGE CODE #1
NEW RANGE CODE #2

NOTES:
1. ALL TIMES ARE TYPICAL UNLESS MARKED OTHERWISE.

1722	
MODEL	RIGHT ASSEMBLY
USED ON	

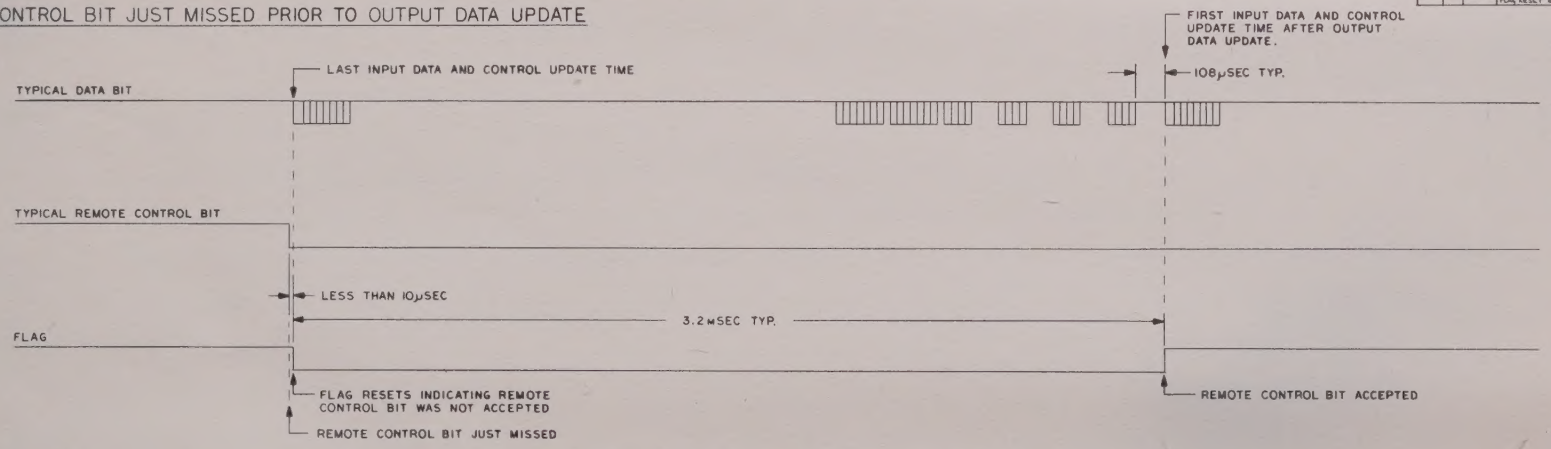
DO NOT SCALE THIS DRAWING	DIMENSIONS TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 6-12-76	SCALE	TITLE TIMING DIAGRAM, MODEL 1722
KEITHLEY INSTRUMENTS CLEVELAND, OHIO	XX ± .01 ANG. ± 1°	DR R. SMITH	SIZE A	
	XXX ± .005 FRAC. ± 1/64	MATERIAL		NO 28248E
	SURFACE MAX	FINISH		

28249D

ZONE	LTR	ECO NO.	REVISION	DATE
	A	5422	RELEASED	11-1-76
	B	5452	ADDED LOW TRUE LOGIC INDICATOR BAR TO AUTORANGED AUTORANGED STROBE, FLAG RESET & TRIGGER MODE.	11-23-76

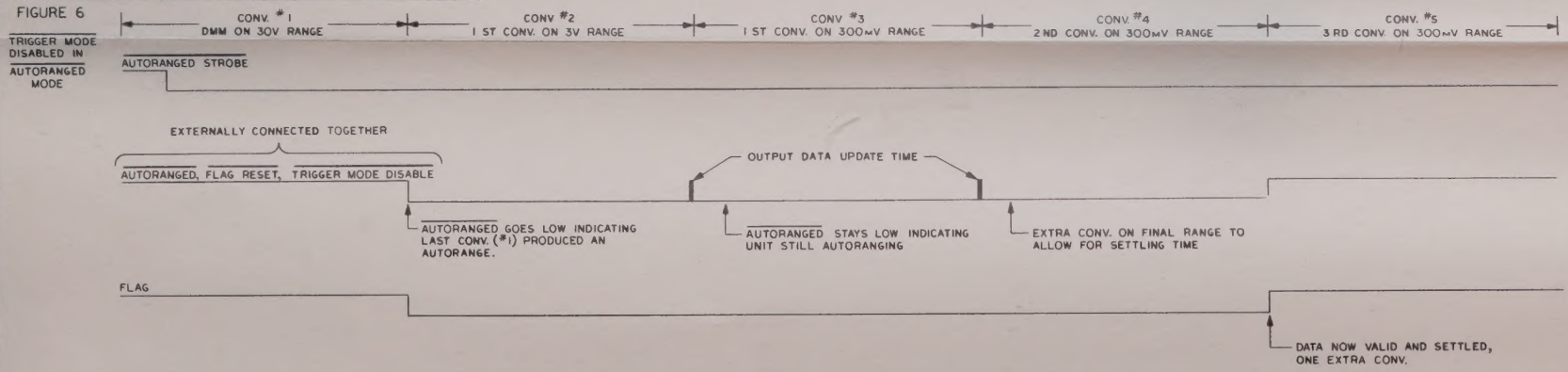
REMOTE CONTROL BIT JUST MISSED PRIOR TO OUTPUT DATA UPDATE

FIGURE 5


FIRST INPUT DATA AND CONTROL UPDATE TIME AFTER OUTPUT DATA UPDATE.
LAST INPUT DATA AND CONTROL UPDATE TIME
108μSEC TYP.
TYPICAL DATA BIT
TYPICAL REMOTE CONTROL BIT
LESS THAN 10μSEC
3.2 mSEC TYP.
FLAG
FLAG RESETS INDICATING REMOTE CONTROL BIT WAS NOT ACCEPTED
REMOTE CONTROL BIT JUST MISSED
REMOTE CONTROL BIT ACCEPTED

USE OF AUTORANGED AND TRIGGER MODE DISABLE

FIGURE 6


CONV. #1 DMM ON 30V RANGE
CONV #2 1 ST CONV. ON 3V RANGE
CONV #3 1 ST CONV. ON 300mV RANGE
CONV #4 2ND CONV. ON 300mV RANGE
CONV. #5 3 RD CONV. ON 300mV RANGE
TRIGGER MODE DISABLED IN AUTORANGED MODE
AUTORANGED STROBE
EXTERNALLY CONNECTED TOGETHER
AUTORANGED, FLAG RESET, TRIGGER MODE DISABLE
OUTPUT DATA UPDATE TIME
AUTORANGED GOES LOW INDICATING LAST CONV. (#1) PRODUCED AN AUTORANGE.
AUTORANGED STAYS LOW INDICATING UNIT STILL AUTORANGING
EXTRA CONV. ON FINAL RANGE TO ALLOW FOR SETTLING TIME
FLAG
DATA NOW VALID AND SETTLED, ONE EXTRA CONV.

1722		
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX ± 0.015 ANG ± 0.1°
XXX ± 0.005 FRAC ± 1/64
SURFACE MAX 63

DATE 4-20-76 SCALE —

DRN R. SMITH

MATERIAL

FINISH

TITLE MODEL 1722 TIMING DIAGRAM

NO. 28249D

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

KEITHLEY INSTRUMENTS, INC.

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY